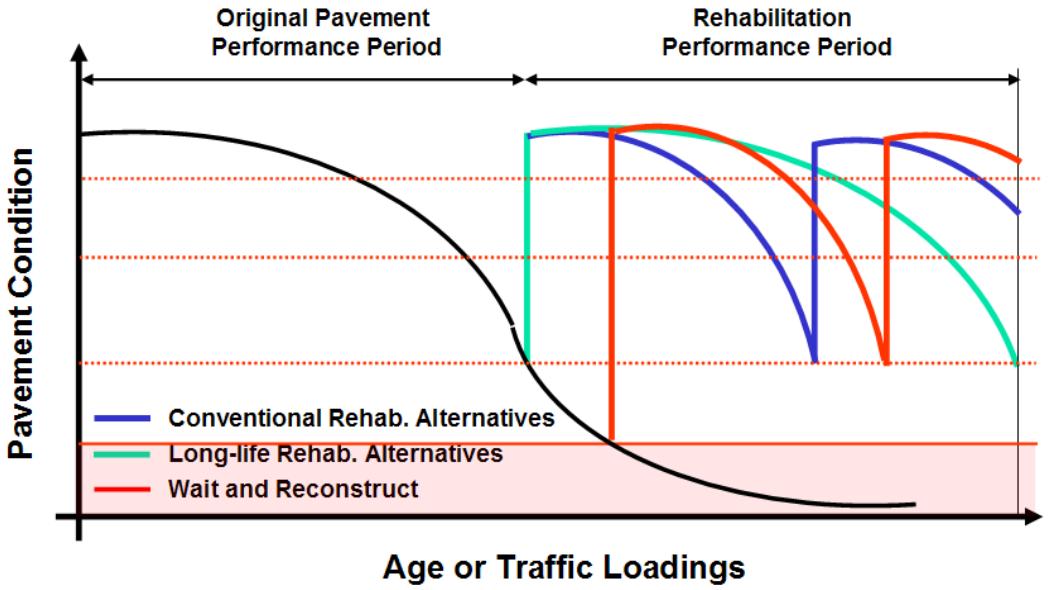
INTERIM

LIFE-CYCLE COST ANALYSIS PROCEDURES MANUAL



Note to the User

To use this manual, the reader must have Life-Cycle Cost Analysis software program *RealCost, Version 2.2.1*. The program can be downloaded from the FHWA, Office of Asset Management Web site at *http://www.fhwa.dot.gov/infrastructure/asstmgmt/lccasoft.htm*

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State of California
Department of Transportation
Pavement Standard Team & Division of Design

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1.0 PURPOSE OF THIS MANUAL

This manual describes life-cycle cost analysis (LCCA) procedures to be used by the employees of the California Department of Transportation (Caltrans) and other personnel working on projects on the State Highway System or other roads/facilities funded by Caltrans. .The manual provides step-by-step instructions for using *RealCost*, a computer software program developed by the Federal Highway Administration (FHWA) that has been chosen by Caltrans as the official software for evaluating the cost effectiveness of alternative pavement designs or implementation strategies for new roadways and for existing roadways requiring a capital preventive maintenance (CapM), rehabilitation, or reconstruction. The instructions describe in detail how to perform an LCCA in order to assure that the project alternatives are analyzed objectively and consistently statewide regardless of who designs, builds, or funds the project.

It is Caltrans' policy that life-cycle cost impacts must be fully taken into account when making project-level decisions. Further discussion on when and how to apply the LCCA can be found in the Highway Design Manual (HDM), Topic 619. This manual is a "living document," as it will be continuously updated as new data and information arrive.

2.0 BACKGROUND

The LCCA is an analytical technique that is built on well-founded economic principles to evaluate long-term alternative investment options. The analysis enables the total cost comparison of competing design alternatives, each of which would be appropriate for implementation to a roadway being considered. By taking into account of all of the relevant costs (agency and user costs) that would occur throughout the life of an alternative, this analytical process helps to identify the lowest cost option to accomplish the project (which ultimately might not be selected after such considerations as available budgets, risk, and political and environmental concerns are

taken into account) and provides other critical information for the overall decision-making process.

The FHWA encourages the use of LCCA in analyzing all major investment decisions where such analyses are likely to increase the efficiency and effectiveness of those decisions.

HDM Topics 612 and 619 identify situations where an LCCA must be performed to assist in determining the most appropriate alternative for a project by comparing the life-cycle costs of:

- Different pavement types (flexible, rigid, or composite);
- Different rehabilitation strategies;
- Different pavement design lives (e.g., five-years vs. ten-years, ten-years vs. twenty-years, twenty-years vs. forty-years, etc.); and
- Different implementation strategies (combining widening and rehabilitation projects vs. building them separately).

3.0 LCCA METHODOLOGY

Once a decision has been made to undertake a project, the LCCA should be conducted as early as possible in the project development process. The level of analysis detail should be consistent with the level of investment.

There are two different approaches in life-cycle cost computation: deterministic and probabilistic. The deterministic approach is a traditional one where the user assigns each LCCA input variable a fixed, discrete value, usually a value most likely to occur based on historical data and user judgment. The probabilistic approach is a relatively new one that accounts for the uncertainty and variation associated with input values. By defining uncertain input variables with frequency (probability) distributions of possible values, this approach allows for simultaneous computation of differing assumptions for many variables. Probability distribution functions for

individual LCCA input variables are still under development at Caltrans, and they are not yet available for use; *therefore this manual only addresses the deterministic approach.*

Following are the steps for performing the LCCA:

1) Establish alternatives;
2) Determine analysis periods;
3) Determine discount rate;
4) Determine maintenance and rehabilitation frequencies;
5) Estimate costs;
6) Calculate life-cycle costs; and
7) Analyze alternatives.

The LCCA procedures described herein were derived from the FHWA's *RealCost User Manual* (2004) and the FHWA's *LCCA Technical Bulletin* (1998), "Life-Cycle Cost Analysis in Pavement Design," both of which can be downloaded from the FHWA Web site at http://www.fhwa.dot.gov/infrastructure/asstmgmt/lccasoft.htm. The additional tables, figures, and other resources included in this manual are specifically developed for Caltrans projects and are to guide the data inputs needed for running *RealCost.*

3.1 Establishing Alternatives

The LCCA begins with the development of alternative pavement designs or implementation strategies that will accomplish the structural and performance objectives for a project. For example, comparisons can be made of flexible pavement versus rigid pavement; rubberized asphalt concrete (RAC) pavement versus conventional hot mixed asphalt (HMA) pavement; HMA mill-and-replace versus HMA overlay; and ten-year design life rehabilitation versus

twenty-year design life rehabilitation. Each competing alternative must be a properly designed, viable pavement structure that would be approved for construction if selected. HDM Topic 619 lists the minimum requirements for when and what to analyze using the LCCA. See HDM Topic 612 for cases requiring a mandatory or advisory design exception.

Table 1 provides some typical alternatives to consider for new construction, widening, rehabilitation, and CapM (pavement rehabilitation) projects that will meet the requirements of HDM Topic 612 and 619. The table provides up to three recommended alternatives for each condition and provides some additional alternatives that may be added to (or in some cases substituted for) the three recommended alternatives.

Table 1. Typical Design Alternatives for Pavement Projects

Pvmt Project Type	Document	Conditions	Alt 1	Alt 2	Alt 3	Other Alternatives that could be considered		
New	PID	20 yr Traffic Index (TI_{20})						
		$TI_{20} > 15$	20 yr Rigid (JPCP)	40 yr Rigid (JPCP)	40 yr Rigid (CRCP)	20 yr Flex[1]	20 yr Composite[2]	40 yr Composite[2]
		$TI_{20} \leq 15$ & ≥ 12	20 yr Flex[6]	40 yr Rigid (JPCP)	40 yr Flex[6]	40 yr Rigid (CRCP)	20 yr Composite[2]	40 yr Composite[2]
		$TI_{20} < 12$	20 yr Flex[6]	40 yr Rigid (JPCP)	40 yr Flex[6]	20 yr Composite[2]	40 yr Composite[2]	
	PR (PA&ED)	PID Preferred Pvmt Type & Life						
		Flexible (20 yr design)	HMA	HMA w. RAC-O	RAC	HMA w. OGFC	RAC w. RAC-O	
		Flexible (40 yr design)	HMA w. RAC-O	RAC w. RAC-O	HMA w. OGFC			
		Rigid (20 yr design)	JPCP	Flex (RAC)	Flex (HMA)			
		Rigid (40 yr design)	JPCP	CRCP[3]	RAC w. RAC-O	Composite[2]	HMA w. RAC-O	
Widening	PID	Exist Road Pvmt Surface						
		Flexible	RSL Flex	20 yr Flex	40 yr Flex	40 yr Composite[2]	20 yr Composite[2]	
		Rigid	RSL Rigid	RSL Flex	40 yr Rigid			
	PR (PA&ED)	PID Preferred Pvmt Type & Life						
		Flexible ($\leq$ 20 yr design)	HMA	HMA w. RAC-O	RAC	HMA w. OGFC	RAC w. RAC-O	
		Flexible ($\geq$ 20 yr design)	HMA w. RAC-O	RAC w. RAC-O	HMA w. OGFC			
		Rigid ($\leq$ 20 yr design)	Rigid	Flex (RAC)	Flex (HMA)			
		Rigid ($\geq$ 20 yr design)	Rigid			Flex (RAC w. RAC-O)	Flex (HMA w. OGFC)	
Roadway Rehabilitation	PSSR	Exist Road Pvmt Surface						
		Flexible	HMA	RAC		HMA w. OGFC	RAC w. RAC-O	
		Flexible w. OGFC	HMA w. OGFC	RAC w. RAC-O				
		Rigid (AADT < 50,000)	10 yr Crack, Seat & Flex Overlay	20 yr Crack, Seat & Flex Overlay	20 yr Lane Replacement	10 yr Crack, Seat & Flex Overlay		
		Rigid (AADT $\geq$ 50,000)	10 yr Crack, Seat & Flex Overlay	20 yr Lane Replacement	40 yr Lane Replacement	20 yr Crack, Seat & Flex Overlay		
CAPM (Pvmt Rehabilitation)	PR	Exist Road Pvmt Surface						
		Flexible	HMA (dense or open graded)	RAC (Type G or O)		Seals[4]	Walruses	Penguins
		Rigid (< 5% slab replacement)	Grinding (Rigid Strategy)	Thin RAC Overlay				
		Rigid ($\geq$ 5% slab replacement)	Grind & slab replacement	Lane Replacement (Rehab)				

Abbreviations:
AADT = Average Annual Daily Traffic
CAPM = Capital Preventive Maintenance
CRCP = Continuously Reinforced Concrete Pavement
HMA = Hot Mixed Asphalt (formerly Asphalt Concrete)
JPCP = Jointed Plain Concrete Pavement
OGFC = Open Graded Friction Course (conventional HMA mix)
RAC = Rubberized Asphalt Concrete
RAC-O = RAC Type O (an open graded friction course with RAC)
RSL = Remaining Service Life. Note per HDM Index 612.3, the pvmt design life cannot be less than project design period.

Notes:
1 - HDM currently does not provide a methodology for flexible pavement design for TI>15. Consult Office of Pavement Design for special design options.
2 - Composite Pvmt may be thin RAC ($\leq$ 0.25') over JPCP or CRCP. Choose the same rigid pvmt type that is being analyzed for one of the other alternatives.
3 - Consider only for $TI_{20} \geq 12$.
4 - See CAPM Guidelines for various types of seals available for CAPM projects.
5 - Match existing rigid pavement type (JPCP, CRCP, etc…)
6 - Assume RAC unless there are specific reasons RAC cannot be used. Document these reasons in PID document. If sufficient information is available, can opt to analyze HMA vs RAC in addition to rigid pavement alternatives.

Note that although these design alternatives should usually work for most of the projects to be built by the State, certain project conditions may require considering different design alternatives. When determining if the LCCA should be done or when selecting design alternatives for the LCCA, be sure that the following rules are met in addition to the requirements found in HDM 612 and 619.

1) When comparing pavements with alternate design lives, at least two of the alternatives must have the same pavement surface [i.e. HMA, RAC, jointed plain concrete pavement (JPCP)]. Exceptions to this rule would be situations where there exists no standard design available for the pavement surface in question with an alternate design life [Examples: no standard flexible pavement design with a Traffic Index > 15. No continuously reinforced concrete pavement (CRCP) designs for High Mountain or High Desert climate regions].

2) If a conventional HMA is proposed as an alternative pavement type, a RAC alternative must also be considered. Note that a RAC alternative will usually require a HMA or rigid pavement foundation and it has limitations on thickness. See HDM Index 631.3 for the latest requirements on how to use RAC.

3) When writing a Project Initiation Document (PID), the LCCA must at least determine which alternate design life is the most cost effective as per HDM 612. Ideally, the type of pavement surface (flexible vs. rigid, HMA vs. RAC, JPCP vs. CRCP) should also be determined during the PID phase. However, because information is often limited during the PID phase, determination of the pavement surface type can be deferred until the Project Approval & Environmental Document phase (PA&ED) or if

a preliminary decision has been made during the PID phase, validity of that decision should be checked and verified during the PA&ED phase.

4) If the pavement design or implementation strategy is changed during the design of the project, the LCCA need to be done again with updated information and this should be documented in a supplemental Project Report or Project Scope Summary Report.

5) The LCCA should not be used for comparing project alternatives that would not yield the similar benefits to the users of the facility (e.g., road rehabilitation versus road capacity expansion) or for comparing projects that would accomplish different objectives (e.g., road realignment versus widening). To perform that sort of analysis, a Benefit-Cost Analysis (BCA), which considers the benefits of an alternative as well as its costs, should be used. For further information on the BCA, refer to the Cal-B/C (California Life-Cycle Benefit/Cost Model) user manuals and technical supplements,which are available from the Division of Transportation Planning at http://www.dot.ca.gov/hq/tpp/planning_tools/tools.htm.

3.2 Determining an Analysis Period

The *analysis period* is the timeframe during which the initial and future costs for the project alternatives will be evaluated. Table 2 provides the common analysis periods to be used when comparing alternatives with same or different pavement design lives. For example, a minimum analysis period of twenty years should be used if both alternatives are designed for a five-year life or if five-year and ten-year design life alternatives are compared; a thirty-five year analysis period should be used if ten-year and twenty-year design life alternatives are compared; and a

fifty-five year analysis period should be used if twenty-year and forty-year design life alternatives are compared.

Table 2. LCCA Analysis Periods

	Alternative 2 Design Life			
Alternative 1 Design Life	5-Yr	10-Yr	20-Yr	40-Yr
5-Yr	20 years	20 years	35 years	
10-Yr	20 years	20 years	35 years	55 years
20-Yr	35 years	35 years	35 years	55 years
40-Yr		55 years	55 years	55 years

The LCCA assumes that the pavement will be properly maintained and rehabilitated to carry the projected traffic over the specified analysis period. Thus, reasonable, feasible, follow-up maintenance and rehabilitation (M&R) strategies after the initial construction must be established for the analysis period, as the pavement ages, its pavement condition will gradually deteriorate to a point where some type of maintenance or rehabilitation treatment is warranted. Figure 1 shows the cycle of construction, pavement condition, and maintenance/rehabilitation that a pavement typically undergoes.

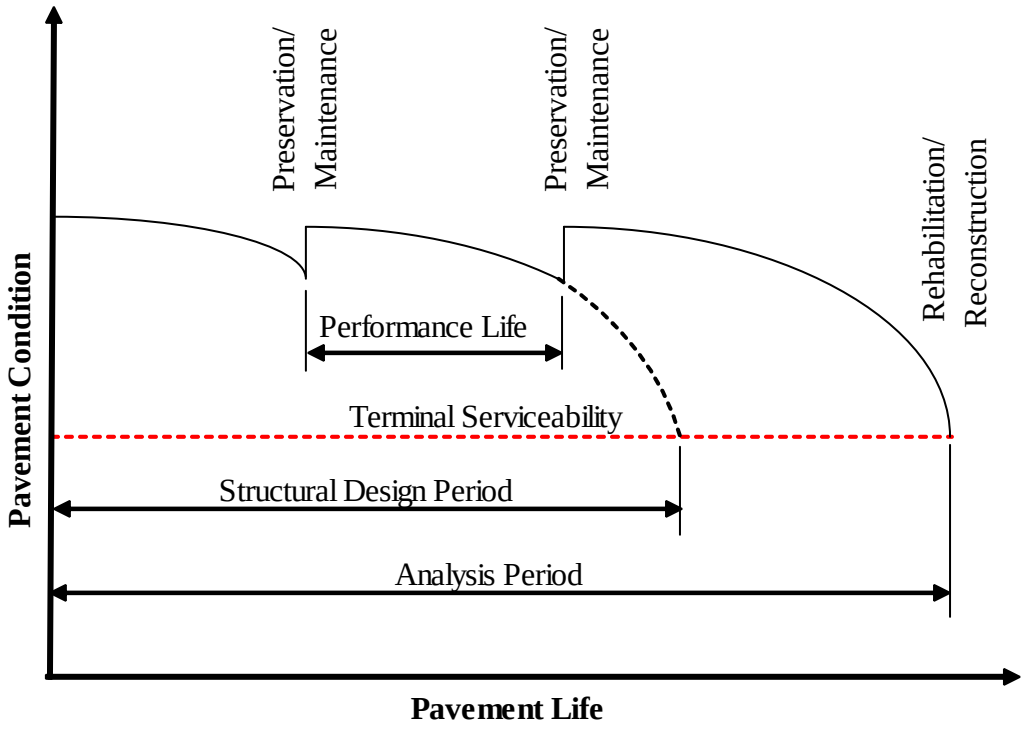


Figure 1. Pavement Condition vs. Pavement Life

Information on pavement performance and M&R strategies for various types of pavements are discussed further in Section 3.4, "Determining Maintenance and Rehabilitation Frequencies."

3.3 Determining Discount Rate

Discount rate is the interest rate by which future costs (in constant dollars) will be converted to present value. It is commonly known as a "real discount rate" as it reflects only the opportunity value of time, without including the general rate of inflation. Real discount rates typically range from three (3) percent to five (5) percent, representing the prevailing interest rate on borrowed funds less inflation. **Caltrans currently uses a discount rate of four (4) percent in the LCCA of pavement structures.**

3.4 Determining Maintenance and Rehabilitation Frequencies

After the viable project alternatives are identified, a follow-up pavement M&R schedule for each alternative must be determined. Pavement M&R schedules typically identify the sequence and timing of future treatment activities that are required to maintain and rehabilitate the pavement over the analysis period. Typical pavement M&R schedules found in Appendix 2 of this manual are to be used in the LCCA for pavement projects on the State Highway System.

Table 3 shows examples of pavement M&R schedules included in Appendix 2 for RAC pavements in the State's "coastal" climate region. These typical schedules are derived from the "Pavement M&R Decision Trees" prepared by each Caltrans district and experience with pavement performance in California. As shown in Table 3, they include only the future CapM, rehabilitation, and reconstruction activities which are to be entered to RealCost in same sequence as future rehabilitations after implementing a project alternative [Note: RealCost allows the user to enter up to six future rehabilitation activities following the initial construction (i.e. project alternative) within the analysis period selected]. Interim maintenance treatments (HM-1 projects and woks by maintenance field crews) to be performed between each scheduled activity have been converted into an annualized maintenance cost ($/lane-mile), which is to be entered separately to RealCost, as discussed further in Section 3.5.2, "Maintenance Costs" and in Section 4.2, "Alternative-Level Inputs."

Table 3. Pavement M&R Schedule Examples

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0		5		10		15		20		25		30		35	
CapM																				
RAC	5	1,2		Year of Action	0		9				19				29					
				Activity Description	RAC CapM (5 yr)		RAC Rehab (10 yr)				RAC CapM (5 yr)				RAC Rehab (10 yr)					
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	9	4,270	10	3,915			9	4,270			10	3,915				
		3		Year of Action	0		9				18				27					
				Activity Description	RAC CapM (5 yr)		RAC CapM (5 yr)				RAC CapM (5 yr)				Reconst. (20 yr)					
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	9	4,270	9	4,270			9	4,270			20	1,167				
	10	1,2		Year of Action	0				13										35	
				Activity Description	RAC CapM (10 yr)				RAC Rehab (20 yr)										RAC CapM (10 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10	3,915			25	3,530									10	3,915
		3		Year of Action	0						13		22						35	
				Activity Description	RAC CapM (10 yr)						RAC CapM (5 yr)		RAC CapM (10 yr)						Reconst. (20 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	13	3,057					9	4,270	13	3,057					20	1,167
Rehabilitation																				
RAC	10	1,2,3		Year of Action	0				10		19				29					
				Activity Description	RAC Rehab (10 yr)				RAC CapM (5 yr)		RAC Rehab (10 yr)				RAC CapM (5 yr)					
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10	3,915			9	4,270	10	3,915			9	4,270				
	20	1,2,3		Year of Action	0								25				34			
				Activity Description	RAC Rehab (20 yr)								RAC CapM (5 yr)				RAC Rehab (20 yr)			
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	25	3,530							9	4,270			25	3,530		

In order to find an applicable pavement M&R schedule for a project alternative in Appendix 2, the following information needs to be collected first:

1) *Existing/New pavement type.* This regards to whether the existing/new pavement is flexible (asphalt concrete), rigid (concrete), or composite pavement.
2) *Proposed final pavement surface type*. This regards to what type of final pavement surface is being proposed for the existing/new pavement: namely, HMA, HMA w/ OGFC (Open Graded Friction Course), RAC, or RAC w/ RAC-O (RAC-Open Graded), JPCP (Jointed Plain Concrete Pavement), CRCP (Continuously Reinforced

Concrete Pavement), or Crack, Seat, and AC Overlay. The proposed final surface type is the alternative being investigated for LCCA.

3) *Pavement design life of the proposed alternative.*
4) *Pavement climate region.* This is obtained from "Pavement Climate Regions" map that is available on the Office of Pavement Design Web page at http://www.dot.ca.gov/hq/oppd/pavement/pdindex.htm.
5) *Maintenance Service Level (MSL).* The MSL is obtained from the District Maintenance Engineer. MSL is the state highway classification used by the Division of Maintenance for maintenance program purposes. MSL is further defined in the Department's annual State of the Pavement Report.

Once all the above information is known, follow the logical sequence, shown in Figure 2**Error! Reference source not found.**, to find which table in Appendix 2 contains an applicable pavement M&R schedule for a project alternative being proposed within the designated climate region. Then, select the applicable schedule based upon proposed project type (new construction/reconstruction, CapM, or Rehabilitation), proposed final pavement surface type, proposed pavement design life, and maintenance service level of the pavement. In cases when two optional schedules (option 1 and option 2) are provided, either option may be selected for the analysis provided that the same option is selected for each alternative.

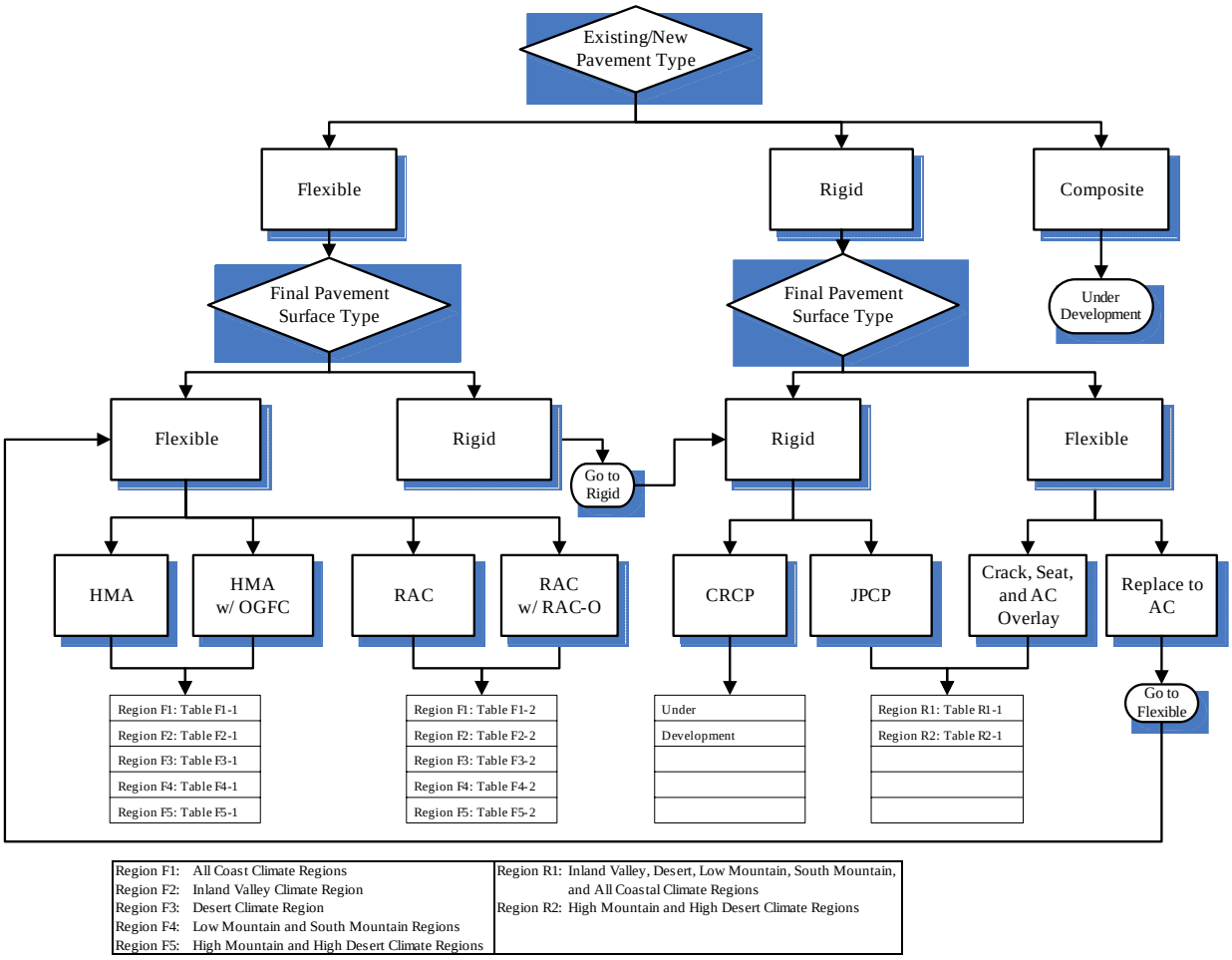


Figure 2. Pavement M&R Schedule Determination Flow Chart

3.5 Estimating Costs

Life cycle costs include initial costs, maintenance costs, rehabilitation (including CapM) costs, user costs, and remaining service life value.

3.5.1 Initial Costs

Initial costs include estimated construction costs as well as project support costs (for design, environment, construction administration and inspection, project management, etc.) to be borne by an agency for implementing a project alternative.

3.5.1.1 *Construction costs* for each alternative should be determined from the engineer's estimates if available [see the Project Development Procedures Manual (PDPM) for estimating costs and the summary sheets included in the PID and the Project Report (PR)] and should include all the costs required for mainline pavement, base, subbase, shoulders, shoulder base, shoulder subbase, drainage, joint seals, earthwork, traffic control, time-related overhead, mobilization, supplemental work, and contingencies. Construction costs common to both alternatives — such as bridges, traffic signage, and striping — may be excluded if those costs can be identified with little effort.

3.5.1.2 *Project support costs* should be decided based on the costs identified in the proposed work plan for project alternatives. Where work plan data are not available yet, the project support cost multipliers shown in Table **Error! Reference source not found.**4 may be used to estimate project support costs that will likely be required for a project alternative.

Table 4. Agency Project Support Cost Multipliers

Type of Project		Range of Project ($)	Multiplier w/ Right-of-Way	Multiplier w/o Right-of-Way
New Construction	Small	750,000 - 5,000,000	0.47	0.39
	Medium	5,000,001 - 20,000,000	0.31	0.29
	Large	20,000,001 - 35,000,000	0.25	0.23
	Very Large	35,000,001 - Up	0.24	0.20
Widening	Small	750,000 - 2,500,000	0.56	0.52
	Medium	2,500,001 - 5,000,000	0.39	0.35
	Large	5,000,001 - 15,000,000	0.28	0.26
	Very Large	15,000,001 - Up	0.25	0.24
CAPM	Small	750,000 - 2,000,000	0.19	0.19
	Medium	2,000,001 - 5,000,000	0.18	0.15
	Large	5,000,001 - Up	0.16	0.13
Rehabilitation	Small	750,000 - 2,000,000	0.35	0.31
	Medium	2,000,001 - 5,000,000	0.28	0.26
	Large	5,000,001 - Up	0.20	0.19
Realignment	Small	750,000 - 2,000,000	0.65	0.60
	Medium	2,000,001 - 5,000,000	0.67	0.58
	Large	5,000,001 - Up	0.31	0.29

Suppose that one of alternatives being considered is a five-year CapM (HMA overlay) with an estimated construction cost of $ 4.0 million. Corresponding project support cost multipliers in Table 4 for this CapM alternative would be 0.18 with right-of-way and 0.15 without right-of-way, respectively. Accordingly, the respective initial costs for this alternative would be estimated at $4.72 million ($4.0 million for construction and $0.72 million for project supports) with right-of-way and $4.6 million ($4.0 million for construction and $0.6 million for project supports) if the project does not require right-of-way.

3.5.2 Maintenance Costs

Maintenance costs include costs for preventive or corrective maintenances, such as joint and crack sealing, void undersealing, chip seal, patching, spall repair, individual slab replacements, thin HMA overlay, etc., whose purpose is to preserve or to extend the service life of previously carried-out CapM, rehabilitation or reconstruction activity. The maintenance costs to use for the

LCCA are the annualized costs found in the applicable pavement M&R schedules in Appendix 2, selected in accordance with the requirements found in Section 3.4, "Determining Maintenance and Rehabilitation Frequencies." These annualized costs are based on the "Pavement M&R Decision Trees" prepared by each Caltrans district and the historical cost data collected by the Division of Maintenance.

3.5.3 Rehabilitation Costs

Rehabilitation costs are associated with future CapM, rehabilitation and/or reconstruction activities scheduled to be performed after implementing a project alternative. Rehabilitation costs for a particular activity should include costs for project support and costs for all the appurtenant and supplemental works to drainage, safety, and other features, made necessary by the activity.

Table 5 and Table 6 summarize the average lane-mile construction costs (excluding project support costs) of various types of CapM, rehabilitation, and reconstruction projects funded by Caltrans over the last six years (fiscal year 1999 to 2004). After selecting an applicable pavement M&R schedule for the project alternative (as discussed in Section 3.4, "Determining Maintenance and Rehabilitation Frequencies"), these average costs shall be used for estimating costs of future rehabilitation activities (including CapM and reconstruction) included in the selected schedule except that for those future rehabilitation activities, which are categorized as same as the initial construction being proposed (i.e. project alternative), the user can assume rehabilitation costs to be the same as the initial costs estimated for the project alternative. For example, if a project alternative being proposed is a ten-year rehabilitation (HMA overlay) and the selected pavement M&R schedule calls for another 10-year rehabilitation in future, the user can use the initial costs of the project alternative as the rehabilitation costs for the repeated future activity.

Table 5. Caltrans M&R Construction Unit Costs for Flexible/Rigid Pavements (FY 1999-2004)

Pavement Design Life (years)	Strategy Alternative ("State of The Pavement" Designations)	Maint. Service Level	$/Lane-Mile		
			Minimum	Maximum	Weighted Average
CapM					
5	HMA Overlay (ACOL FLEX, CAPM)	1&2	41,664	191,183	**97,000**
		3	68,122	149,302	**106,000**
	HMA Mill & Replace (MILL & REPL AC, CAPM)	1&2	47,622	184,904	**95,000**
		3	--	--	--
	RAC Overlay (RUBBERIZED AC, CAPM)	1&2	28,245	220,433	**92,000**
		3	31,791	157,067	**85,000**
	RAC Mill & Replace	1&2	--	--	--
		3	--	--	--
10	HMA Overlay*	1&2	--	--	**115,000**
		3	--	--	**126,000**
	HMA Mill & Replace*	1&2	--	--	**113,000**
		3	--	--	--
	RAC Overlay*	1&2	--	--	**109,000**
		3	--	--	**101,000**
	RAC Mill & Replace*	1&2	--	--	--
		3	--	--	--
Rehabilitation					
10	HMA Overlay (ACOL FLEX, REHAB)	1&2	133,611	737,800	**306,000**
		3	--	--	--
	HMA Mill & Replace (MILL & REPL AC, REHAB)	1&2	146,269	979,310	**283,000**
		3	222,700	925,556	**302,000**
	RAC Overlay (RUBBERIZED AC, REHAB)	1&2	105,802	781,818	**251,000**
		3	--	--	--
	RAC Mill & Replace	1&2	--	--	--
		3	--	--	--
20	HMA Overlay*	1&2	--	--	**340,000**
		3	--	--	--
	HMA Mill & Replace*	1&2	--	--	**314,000**
		3	--	--	**335,000**
	RAC Overlay*	1&2	--	--	**279,000**
		3	--	--	--
	RAC Mill & Replace*	1&2	--	--	--
		3	--	--	--

* Based upon the 2005 Caltrans' study, "Pavement Service Life Cost Analysis," by the Division of Design.

Table 6. Caltrans M&R Construction Unit Costs for Jointed Plain Concrete Pavements Only (FY 1999-2004)

Pavement Design Life (years)	Strategy Alternative ("State of The Pavement" Designations)	Maint. Service Level	$/Lane-Mile		
			Minimum	Maximum	Weighted Average
CapM					
5	HMA Overlay (ACOL RIGID, CAPM)	1,2,3	68,203	101,856	**81,000**
	Conc. Pvmt Rehab #1*	1,2,3	--	--	**73,000**
	Conc. Pvmt Rehab #2* (CPR, CAPM)	1,2,3	38,826	167,083	**84,000**
	Grind Rigid Pvmt (GRINDING, CAPM)	1,2,3	28,856	191,058	**93,000**
10	HMA Overlay*	1,2,3	--	--	**96,000**
	Conc. Pvmt Rehab #3*	1,2,3	--	--	**114,000**
	Grind Rigid Pvmt	1,2,3	--	--	**111,000**
Rehabilitation					
10	Crack, Seat, & HMA Overlay (ACOL RIGID, REHAB)	1,2,3	91,768	773,626	**251,000**
	Conc. Roadway Rehabilitation (GRINDING, REHAB)	1,2,3	172,820	259,722	**215,000**
20	Crack, Seat, & HMA Overlay*	1,2,3	--	--	**279,000**
	Lane Replacement (CPR, REHAB)	1,2,3	132,843	633,730	**274,000**
	Unbonded Overlay (PCC OVERLAY)	1,2,3	979,710	979,710	**980,000**

* Based upon the 2005 Caltrans' study, "Pavement Service Life Cost Analysis," by the Division of Design.

For those future rehabilitation activities, which are not same as the initial construction (i.e. project alternative) in terms of design life and/or project type (CapM, rehabilitation or reconstruction), follow the steps described below to estimate their costs:

1) Decide on the appropriate strategy alternative for a future rehabilitation activity based upon the final pavement surface proposed in the project alternative (for example, "HMA Mill & Replace" for a five-year CapM to be followed after implementing a project alternative of ten-year rehabilitation "HMA Overlay")
2) Find the average lane-mile construction cost for the selected strategy alternative from Table 5 or Table 6 and multiply it with the total number of lane-miles to be treated to obtain the total construction cost.
3) Find the applicable project support cost multiplier from Table 4 in Section 3.5.1.2, "Project Support Costs" and calculate the project support costs.
4) Add the project support costs to the total construction cost to get the total cost for rehabilitation, which is entered to RealCost as "Agency Construction Cost" for future rehabilitation activities, as discussed further in Section 4.2, "Alternative-Level Inputs."

3.5.4 User Costs

Best-practice LCCA calls for consideration of not only agency costs, but also costs to facility users. *User costs* include travel time costs, vehicle operating costs, and crash costs incurred by the traveling public. Such user costs typically arise when work zones are imposed for fieldwork, which restricts the normal capacity of the facility and reduces traffic flow. *User costs* are also incurred during normal operations but they are often similar between project alternatives and

may be removed from most analyses. Additional user costs resulting from work zones can become a significant factor when a large queue occurs in one alternative but not in the other.

3.5.5 Remaining Service Life Value

If a project alternative has a service life that exceed the analysis period, any service life exceeding the analysis period is known as remaining service life (RSL). This manual assumes that if the pavement M&R schedule selected for a project alternative includes any future rehabilitation activities (including CapM and reconstruction) within the analysis period after implementing the project alternative, all the rehabilitation activities (including the project alternative being proposed as the initial construction) preceding the last rehabilitation activity will have no effective RSL at the end of the analysis period. The RSL value of a project alternative at the end of the analysis period will then be calculated based upon total cost (agency and user costs) of the last rehabilitation activity scheduled to be done on the pavement and the percentage of service life remaining at the end of the analysis period. This is how RealCost calculates the RSL value of a project alternative (i.e., prorated share of total cost of last rehabilitation activity), if the user choose to include both agency cost RSL value and user cost RSL value in computing life-cycle cost of the project alternative (see the instructions in Section 4.1.2, “Analysis Options”)

3.6 Calculating Life-Cycle Costs

This step, *calculating life-cycle costs*, involves calculation of the total life-cycle costs of each alternative so that they may be directly compared. However, because dollars spent at different times have different present values, the anticipated costs for future rehabilitation activities for

each alternative need to converted to their value at a common point in time using an economic concept known as “discounting”.

A number of techniques based upon the concept of discounting are available. The FHWA recommends the present value (PV) approach which brings initial and future costs to a single point in time, usually the present or the time of the first cost outlay. The formula to discount future costs to PV is

$$PV = F \frac{1}{(1+i)^n}$$

where F = future cost at the end of n^{th} years
i = discount rate
n = number of years

However, the equivalent uniform annual cost (EUAC) approach is also commonly used. It produces the yearly costs of an alternative as if they occurred uniformly throughout the analysis period. The PV of this steam of EUAC’s is the same as the PV of the actual cost stream. Whether PV or EUAC is used, the decision supported by the analysis will be same.

3.7 Analyzing Alternatives

This step, *analyzing alternatives*, involves analyzing and interpreting the LCCA results from the previous step, *calculating life-cycle costs*.

There are many factors from which to choose when beginning the comparison. For example, one of the first things to consider might be the user costs proportion comprising total life-cycle costs for the project alternatives. For projects proposed on highway corridors with large traffic volumes, user costs can be significantly greater than agency costs, so it might be necessary to consider assigning a weighting factor to adjust the calculated user costs. These user

costs for each alternative adjusted or not, can then be compared to see if one of them has a disproportionately high or low impact on users.

If the lowest agency cost alternative has a disproportionately high user cost impact, this information should be used either to revisit the alternative's traffic management aspect or to reconsider an alternative that might have somewhat higher agency costs but much lower user costs.

The lowest agency cost alternative may not necessarily be the best solution since there are also other factors that should be addressed, such as safety and air pollution, and non-user and business impacts resulting from reduced or restricted traffic. If a higher life-cycle cost alternative is selected over a lower cost one, the justification for the decision should be documented in the PID, PR, or other appropriate project document. In these instances, design exceptions may be needed as well (see HDM Topic 612). However, for analysis purposes, project alternatives whose life-cycle costs are within 10 percent of each other will be considered to be equivalent, meaning that either one can be considered to have the lower life-cycle cost.

4.0 USING *REALCOST*

In order to prepare a life-cycle cost estimate using *RealCost*, install version 2.2.1 onto your computer. The software can be obtained by downloading it from the FHWA's Office of Asset Management Web site: http://www.fhwa.dot.gov/infrastructure/asstmgmt/lccasoft.htm. Follow the installation instructions provided on the Web site. [Because *RealCost* is an add-on program designed to run in Microsoft *Excel* 2000 (or later), it does not require installation by Caltrans' IT staff.] After you install it, select "*RealCost* 2.2" from the *Windows* "Start Menu" (Programs > *RealCost* > *RealCost* 2.2) to launch the program.

When prompted for Macro options, choose "Enable Macros" to run *RealCost*. When it opens, an "Input Spreadsheet" window — which resembles an *Excel* spreadsheet — appears onscreen. Immediately after that window appears, the "Switchboard" panel opens on top of it (see Figure 3). This Switchboard provides two options for inputting values. This manual contains instructions for entering information by using the Switchboard, but if you want to directly input your values into the Input Worksheet, you can close the Switchboard by clicking the "x" in its upper right-hand corner. If you want to restore it later, you can do so by clicking "RealCost" on the menu bar at the top of the window, and selecting "RealCost Switchboard."

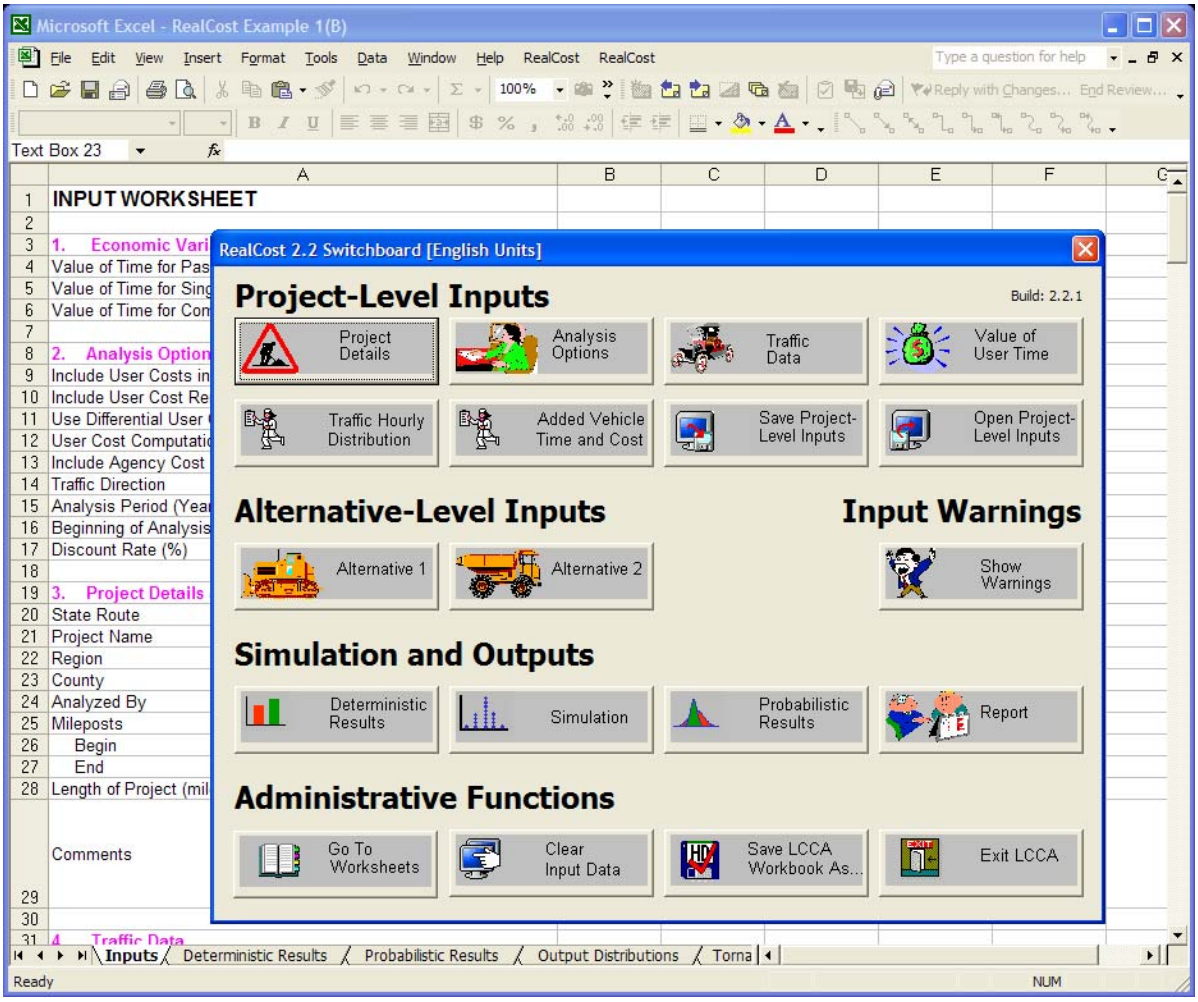


Figure 3. *RealCost* Input Worksheet

As Figure 3 shows, the Switchboard consists of five sections: Project-Level Inputs; Alternative-Level Inputs; Input Warnings; Simulation and Output; and Administrative Functions. These five items and their functions are discussed in Sections 4.1 through 4.5 *(*Note: most of the functions available from the Switchboard are also accessible by selecting the "RealCost" menu item in the Microsoft *Excel* menu bar).

4.1 Project-Level Inputs

RealCost requires two levels of information. The first, "Project-Level Inputs," which are discussed in this section, are project-level data that applies to all the project alternatives being considered. The second information level, "Alternative-Level Inputs" (discussed in Section 4.2), are data that define the differences between project alternatives (e.g., agency costs and work zone specifics for each alternative's component activities). To emphasize the difference between the two types of inputs, *RealCost* requires that they be entered separately.

4.1.1 Project Details

The "Project Details Form" (Figure 4) is used to enter the project documentation details. Enter the data according to the field names. Note that data entered here will not be used in the analysis. Once you have entered all the project documentation details, click the "Ok" button to return to the Switchboard or the "Cancel" button to start over.

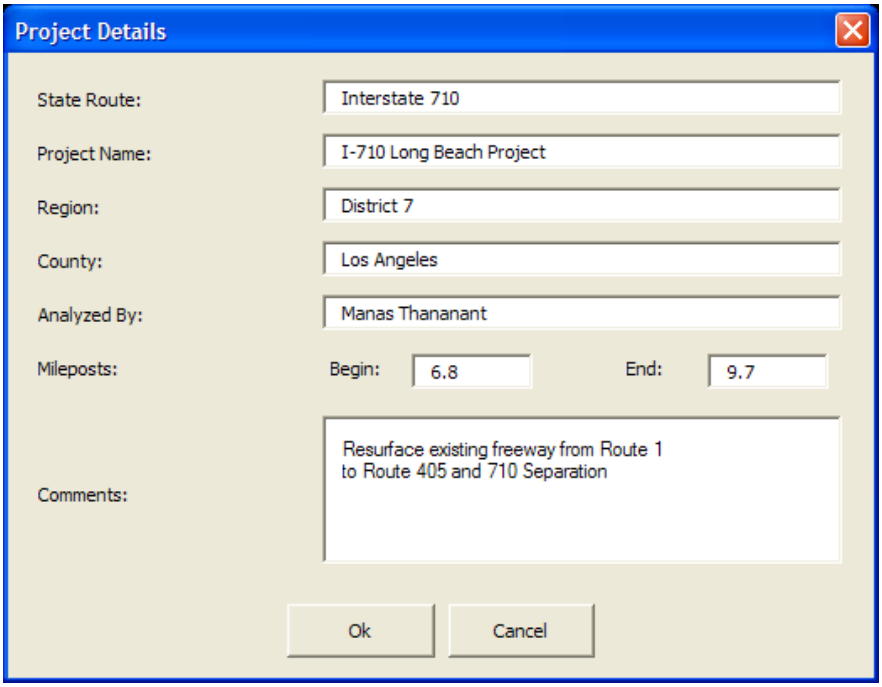


Figure 4. Project Details Form

4.1.2 Analysis Options

The "Analysis Options Form" (Figure 5) is used to define the user options that will actually be applied in analyzing the project alternatives. In this sense, this is where you begin the actual analysis. The data inputs and analysis options available on this form are detailed below.

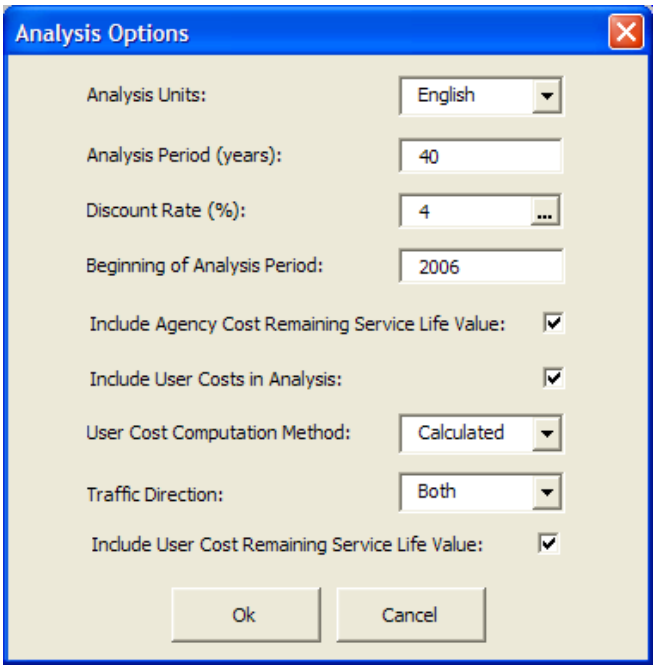


Figure 5. Analysis Options Form

- *Analysis Units*: Select either "English" or "Metric" to set the format in which you want your analysis to appear.
- *Analysis Periods (years)*: Enter an analysis period in years during which project alternatives will be compared. Refer to Table 2 in Section 3.2, "Determining an Analysis Period," to decide on the common analysis period appropriate to the design lives of project alternatives being considered. (Note: The *Analysis Period* in *RealCost* has an expected range of one to forty years. Entering a value greater than forty years will result in the warning message, "Out of Range." The message, however, does not signal an error in the input data. The program will still run and correctly calculate the input data: see Appendix 1.).
- *Discount Rate (%)*: Enter the Caltrans default value of four (4) percent for the deterministic analysis.
- *Beginning of Analysis Period*: Enter the current year or the year in which the project alternative will be undertaken or built.

- *Include Agency Cost Remaining Service Life Value:* Click the checkbox to have *RealCost* include the RSL value of a project alternative [i.e., prorated share of total cost (including agency and user costs) of last rehabilitation activity] in computing life-cycle cost of the project alternative.
- *Include User Costs in Analysis:* Click the checkbox to have *RealCost* include user costs in the analysis and display the calculated user costs results.
- *User Cost Computation Method:* Select "Calculated" to have *RealCost* calculate user costs based on project-specific input data.
- *Traffic Direction:* Directs *RealCost* to calculate user costs for the "inbound" lanes, the "outbound" lanes, or "both" inbound and outbound lanes. Select the traffic lanes which will be affected by work zone operations.
- *Include User Cost Remaining Service Life Value:* Click the checkbox to have *RealCost* include the RSL value of a project alternative [i.e., prorated share of total cost (including agency and user costs) of last rehabilitation activity] in computing life-cycle cost of the project alternative.

Once you have defined all the analysis options, click the "Ok" button to return to the Switchboard or the "Cancel" button to start again.

4.1.3 Traffic Data

The "Traffic Data Form" (Figure 6) is used to enter project-specific traffic data that will be used exclusively to calculate work zone user costs in accordance with the method outlined in the FHWA's *LCCA Technical Bulletin* (1998), "Life-Cycle Cost Analysis in Pavement Design." Information on traffic data is typically included in the PR, the Project Study Report (PSR), or the Plans, Specifications, and Estimate (PS&E). If none of these sources has the data, you can obtain

it from the Division of Traffic Operations (TO) Web site at http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/index.htm or from a specific location noted in this manual. The traffic data inputs are described below.

The traffic data inputs are described below.

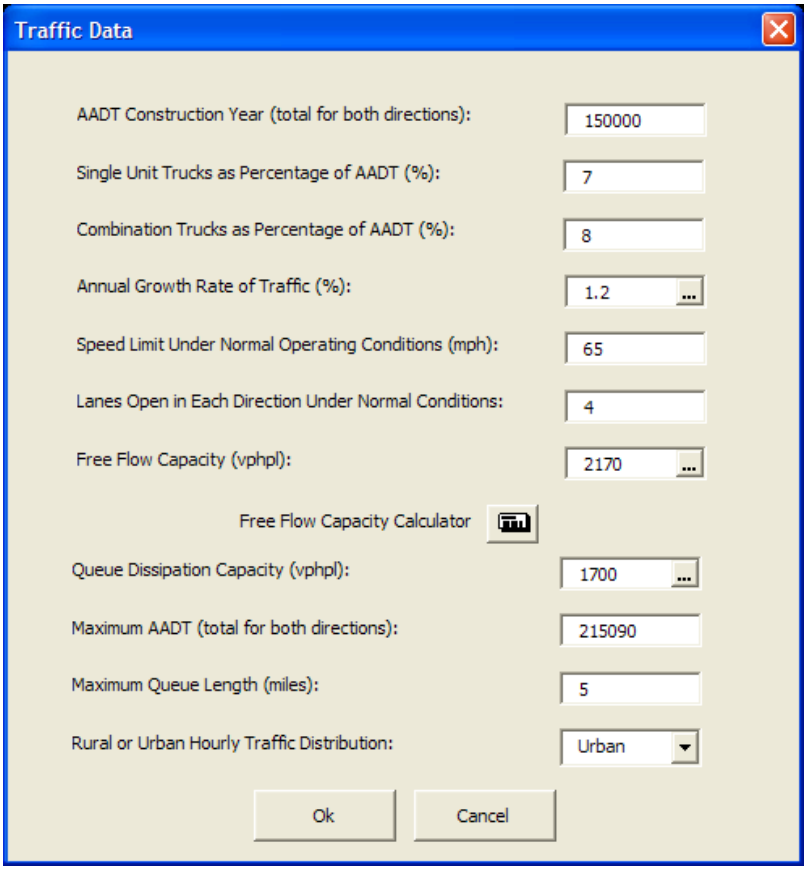


Figure 6. Traffic Data Form

- *AADT Construction Year (total for both directions)*: Enter the annual average daily traffic (AADT) for both directions in the initial construction year or base year of the analysis.
- *Single Unit Trucks as Percentage of AADT (%):* Enter the percentage of the AADT that is single unit trucks (i.e., commercial trucks with two-axles and four tires or more).

- *Combination Trucks as Percentage of AADT (%):* Enter the percentage of the AADT that is combination trucks (i.e., commercial trucks with three axles or more).
- *Annual Growth Rate of Traffic (%)*: Enter the percentage by which the AADT in both directions will increase each year. If a project-specific rate is not available, refer to Table 7 to determine an approximate growth rate appropriate for the project site location. The annual traffic percentage increases included in the table are based upon the projected state highway traffic volume estimates produced by the Division of Transportation System Information (TSI).

Table 7. Example of State Highway Annual Traffic Growth

Road Functional Class	Descriptions	2005 AADT			2025 AADT			Annual % Increase				Remarks
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Standard Deviation	
1	Rural Principal Arterial - Interstate	11,000	168,000	48,940	21,500	237,000	76,755	0.996%	1.066%	1.027%	0.013%	57 Samples
2	Rural Principal Arterial - Other	1,250	112,500	23,721	1,640	193,000	39,397	0.975%	1.060%	1.024%	0.010%	120 Samples
Rural Sub-total		1,250	168,000	31,843	1,640	237,000	51,428	0.975%	1.066%	1.025%	0.011%	177 Samples
11	Urban Principal Arterial - Interstate	16,800	382,000	192,725	30,700	553,000	273,557	1.005%	1.043%	1.019%	0.006%	119Samples
12	Urban Principal Arterial - Other Freeways or Expressways	880	311,000	96,583	2,000	458,000	143,227	0.958%	1.060%	1.020%	0.012%	158 Samples
14	Urban Principal Arterial - Other	3,300	85,000	28,332	5,460	324,000	48,131	0.995%	1.119%	1.025%	0.015%	121 Samples
Urban Sub-total		880	382,000	104,579	2,000	553,000	153,412	0.958%	1.119%	1.021%	0.012%	398 Samples
Total		880	382,000	82,735	1,640	553,000	122,555	0.958%	1.119%	1.022%	0.013%	575 Samples

- *Speed Limit under Normal Operating Conditions (mph)*: Enter the posted speed limit at the project site location. If a roadway is being newly built, enter an anticipated speed limit.
- *Lanes Open in Each Direction under Normal Conditions*: Enter the number of lanes open to traffic in each direction during normal operating hours. For widening of existing roadway, enter the number of existing lanes, not the future number of lanes. If a roadway is being newly built, enter the designed number of lanes.
- *Free Flow Capacity (vphpl)*: Enter the number of vehicles per hour per lane (vphph) during normal operating hours. Refer to Table 8 for the recommended values for a typical freeway in a rural and in an urban area. Alternatively, you may click the "Free

Flow Capacity Calculator" to open a form that calculates free flow capacities based upon the *Highway Capacity Manual (1994)*, 3rd Ed. To use the calculator, enter the following project-specific information: number of lanes in each direction, lane width, proportion of trucks and buses, upgrade, upgrade length, obstruction on two sides, and distance to obstruction/shoulder width.

Table 8. Traffic Input Values

	Two-Lane Freeways[1] (in rural areas)			Multi-Lane Freeways[1] (in urban areas)		
Type of Terrain	Leveled	Rolling	Mountainous	Leveled	Rolling	Mountainous
Free Flow Capacity (vphpl)	1,620	1,480	1,260	2,170	1,950	1,620
Queue Dissipation Capacity (vphpl)	1,710	1,570	1,330	1,700	1,530	1,270
Maximum AADT (total for both directions)[2]	81,910	74,780	63,700	215,090	193,220	160,560
Work Zone Capacity (vphpl)[3]	1,050	960	820	1,510	1,360	1,130
Work Zone Speed Limit	30 mph (55 mph to 65 mph as normal speed limit)			55 mph (65 mph to 70 mph as normal speed limit)		
Maximum Queue Length[4]	7.0 miles if the estimated maximum queue length is longer than 7.0 miles			5.0 miles if the estimated maximum queue length is longer than 5.0 miles		

(1) 10.0 % and 12.0 % of AADT assmed as truck volume for rural freeways and urban freeways, respectively
(2) 2 lanes for rural freeways and 4 lanes for urban freeways assumed
(3) 1 lane open for rural freeways, two or more lanes open for urban freeways assumed
(4) Based upon the demand-capacity model described in Appendix 3

- *Queue Dissipation Capacity (vphpl*): Enter the vehicles per hour per lane capacity of each lane during queue-dissipation operating conditions. Refer to Table 8 for the recommended values for a typical freeway in a rural and in an urban area.
- *Maximum AADT (total for both directions)*: Enter the maximum AADT in both directions at which the traffic growth will be capped. If traffic grows beyond this value, it will be substituted for the computed future AADT value and future user costs will be calculated based upon it. Refer to Table 8 for the recommended values for a typical freeway in a rural and in an urban area.
- *Maximum Queue Length (miles)*: Enter a practical maximum length of queue in miles. Reasonable maximum queue length could be one or two exits prior to the work zone

or an exit that leads to a reasonable alternate route. Queue-related user costs, which are based upon queue length, will be calculated with this value in cases when the *RealCost*-calculated queue lengths exceed this value. If a project-specific value is not available, enter five (5) miles for urban freeways and seven (7) miles for rural freeways. *(Note*: Appendix 3 explains briefly the demand-capacity model — queuing theory — that *RealCost* uses in calculating maximum queue length.)

- *Rural or Urban Hourly Traffic Distribution*: Select "Rural" or "Urban" depending on the project site location. Refer to the PR for the roadway classification assigned to the project site. For details on Caltrans' roadway classifications, visit the TSI web site at http://www.dot.ca.gov/hq/tsip/hpms/Page1.php.

Once you have entered all the traffic data, click the "Ok" button to return to the Switchboard or the "Cancel" button to start over.

4.1.4 Value of User Time

The "Value of User Time Form" (Figure 7) is used to enter the values applied to an hour of user time. The dollar value of use time is typically different for each type of vehicle and is used to calculate user costs associated with delay during work zone operations. Enter $10.46 per hour for passenger cars and $27.83 per hour for both single unit and combination trucks. These dollar values are based upon the Caltrans' Cal-B/C model (2004). Once you have entered the dollar values, click the "Ok" button to return to the Switchboard or the "Cancel" button to start over.

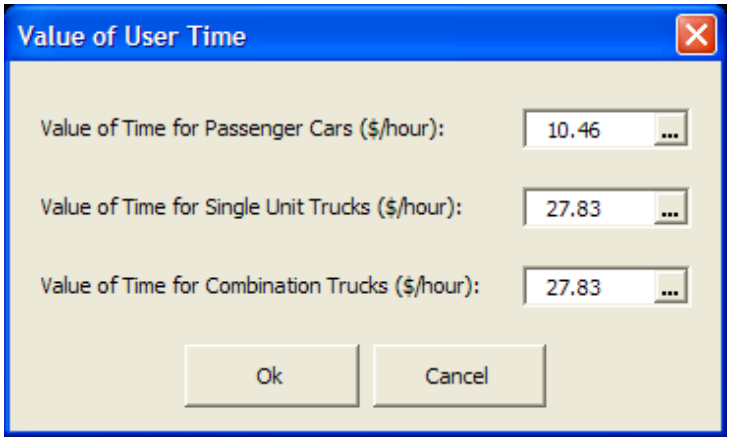


Figure 7. Value of User Time Form

4.1.5 Traffic Hourly Distribution

The "Traffic Hourly Distribution Form" (Figure 8) allows an adjustment to (or restoration of) the default Rural and Urban Traffic hourly distributions, which are used in converting AADT to an hourly traffic distribution. If project-specific data are not available, enter the average hourly values, shown in Table 9, which are generated from the Caltrans' traffic counts data (collected in April 2005 data by TO) on selected highway locations (a total of forty-two samples). Refer to Appendix 4 for the weekday-only and weekend-only traffic hourly distributions.

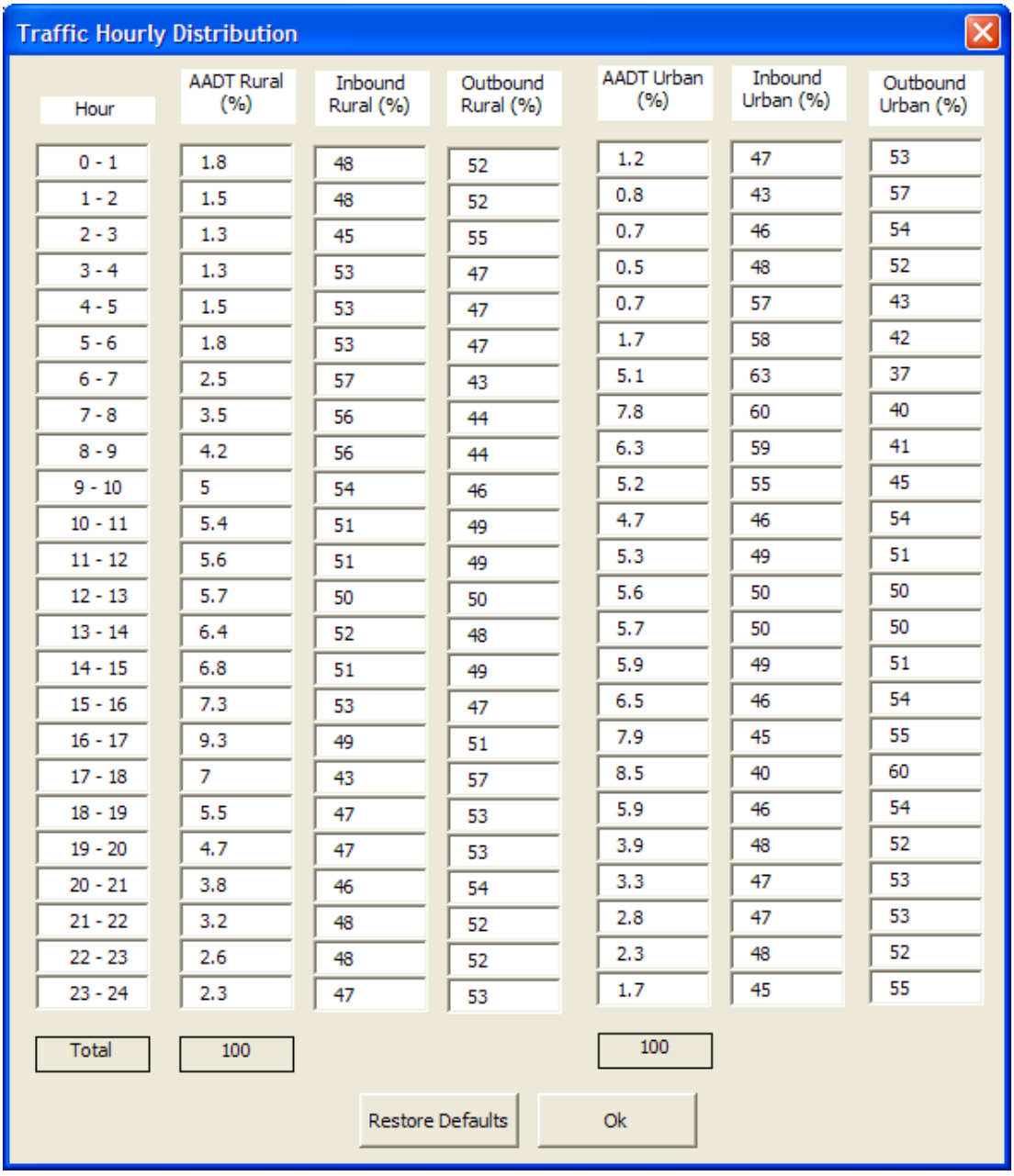


Figure 8. Traffic Hourly Distribution Form

Table 9. Average State Highway Traffic Hourly Distribution

Hour	AADT Rural (%)	Inbound Rural (%)	Outbound Rural (%)	AADT Urban (%)	Inbound Urban (%)	Outbound Urban (%)
0 - 1	1.70	48.5	51.5	1.2	47.9	52.1
1 - 2	1.39	51.3	48.7	0.8	49.0	51.0
2 - 3	1.31	52.4	47.6	0.7	50.4	49.6
3 - 4	1.52	58.0	42.0	0.8	55.5	44.5
4 - 5	2.00	60.0	40.0	1.4	59.9	40.1
5 - 6	3.06	57.9	42.1	2.6	58.9	41.1
6 - 7	4.24	56.3	43.7	4.3	56.9	43.1
7 - 8	4.81	55.7	44.3	5.3	55.9	44.1
8 - 9	4.91	54.3	45.7	5.4	54.5	45.5
9 - 10	5.14	53.3	46.7	5.5	52.9	47.1
10 - 11	5.45	52.2	47.8	5.7	51.0	49.0
11 - 12	5.73	51.0	49.0	6.1	49.8	50.2
12 - 13	5.90	50.9	49.1	6.3	49.0	51.0
13 - 14	5.98	51.3	48.7	6.4	48.4	51.6
14 - 15	6.27	50.9	49.1	6.7	46.8	53.2
15 - 16	6.66	50.1	49.9	7.0	45.6	54.4
16 - 17	6.73	49.0	51.0	6.9	44.7	55.3
17 - 18	6.35	47.3	52.7	6.5	44.8	55.2
18 - 19	5.38	47.3	52.7	5.4	45.5	54.5
19 - 20	4.44	46.3	53.7	4.4	46.0	54.0
20 - 21	3.70	47.3	52.7	3.7	46.4	53.6
21 - 22	3.10	47.6	52.4	3.1	46.9	53.1
22 - 23	2.46	48.1	51.9	2.3	47.9	52.1
23 - 24	1.78	47.5	52.5	1.5	46.3	53.7
	100.0			100.0		

4.1.6 Added Vehicle Time and Stopping Costs

The "Added Time and Vehicle Stopping Costs Form" (Figure 9) is used to adjust the default values for added time and added cost per 1,000 stops. The default values are based upon the National Cooperative Highway Research Program (NCHRP) Study 133 (1996), *Procedures for Estimating Highway User Costs, Air Pollution, and Noise Effects.* These values are used to calculate user delay and vehicle costs due to speed changes that occur during work zone operations. The "Idling Cost per Veh-Hr ($)" is used to calculate the additional vehicle operating costs that result from a traffic queue under stop-and-go conditions.

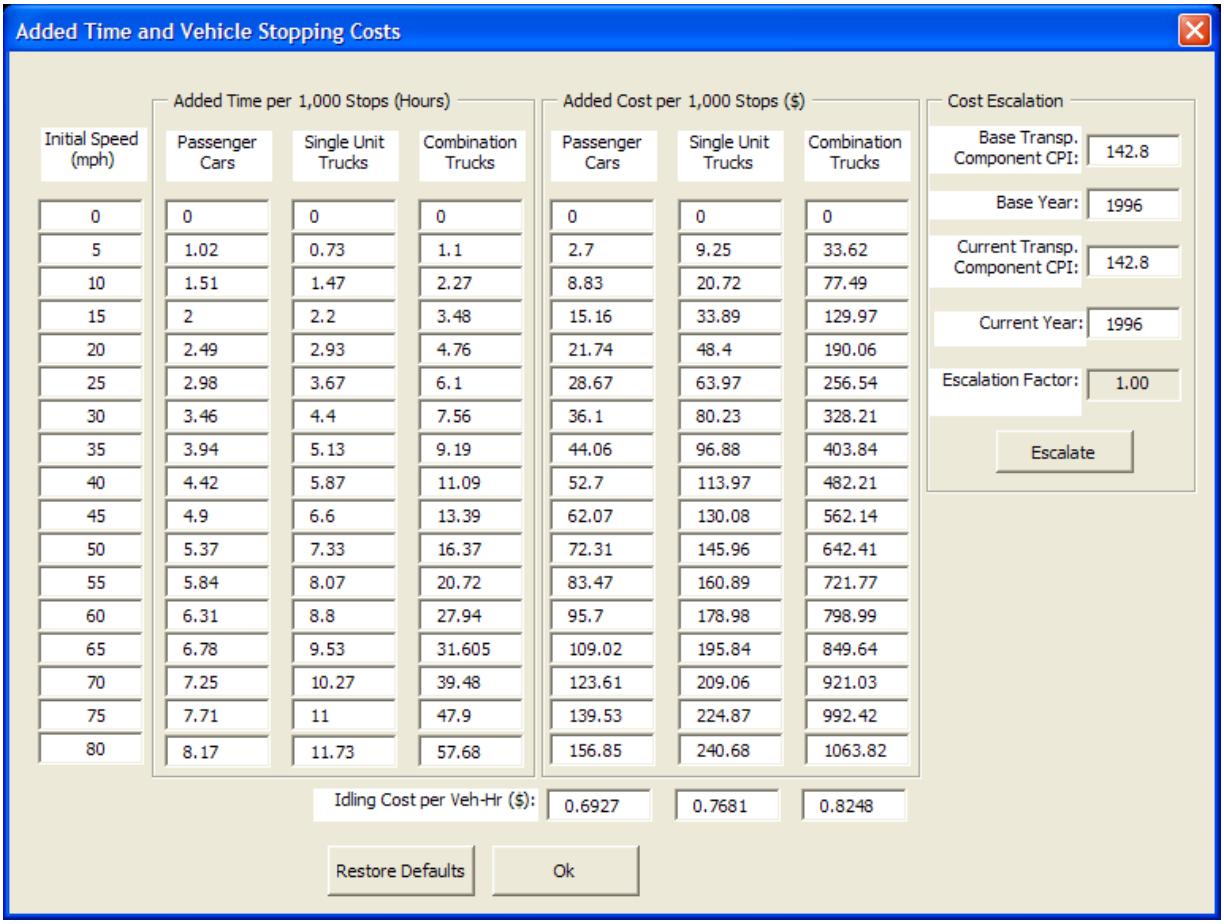


Figure 9. Added Time and Vehicle Stopping Costs Form

The default values, expressed in 1996 dollars, can be adjusted to the current year dollar amounts by entering the transportation-component consumer price index (CPI) of the base (1996) and current years. Table 10 shows the "Consumer Price Indexes for All Urban Consumers" for all items, and the transportation component in the U.S. and the State of California. Since the statewide transportation component CPI's are not currently available, the U.S. transportation-component CPI (which appears in bold text) can be used. For example, for a 2006 year analysis, enter 2006 and 178.0 as the "Current Year" and "Current Transp. Component CPI" values, respectively; then click the "Escalate" button. The program will update the cost data. To get back to the default values, click the "Restore Defaults" button.

Table 10. Consumer Price Indexes for All Urban Consumers

Year	All Items		Transporation		
	US	California	US	LA CMSA*	SF CMSA*
1996	156.9	157.1	**143.0**	144.3	133.5
1997	160.5	160.5	**144.3**	145.2	133.6
1998	163.0	163.7	**141.6**	142.6	132.0
1999	166.6	168.5	**144.4**	146.8	135.8
2000	172.2	174.7	**153.3**	154.2	143.1
2001	177.1	181.8	**154.3**	155.3	143.7
2002	179.9	186.1	**152.9**	154.5	141.0
2003	184.0	190.4	**157.6**	160.3	145.0
2004	188.9	195.3	**163.1**	166.5	149.6
2005	195.6	202.9	**175.2**	176.2	157.3
2006	201.9	210.3	**178.0**	177.1	159.3
2007	206.7	216.6	**177.2**	171.6	156.2
2008	211.8	223.3	**177.9**	167.3	154.1

Source: California Department of Finance, Economic Research Unit
http://www.dof.ca.gov/HTML/FS_DATA/LatestEconData/FS_Price.htm

* LA CMSA: includes counties of Los Angeles, Orange, Riverside, San Bernadino, & Ventura

* SF CMSA: includes counties of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Santa Cruz, Solano, & Sonoma

4.1.7 Save and Open Project-Level Inputs

The “Save Project-Level Inputs” and “Open Project-Level Inputs” buttons are used to save and to retrieve project-level inputs. The user can save the project-level inputs at a preferred location under a user-specified name, and the file will be automatically saved with the *.LCC extension.

4.2 Alternative-Level Inputs

The “Alternative 1 Form” (shown in Figure 10) and “Alternative 2 Form” are identical and are used to enter the alternative-level inputs that define the differences between projects that are being considered (i.e., the agency costs and work zone specifics for initial construction and future rehabilitation activities of each alternative). Each project alternative can include up to six future rehabilitation activities (“Rehabilitation 1” through “Rehabilitation 6”) after the initial construction (i.e., project alternative). The data describing these activities must be entered in the

same sequence for each of the two project alternatives being compared. For example, "Initial Construction" precedes "Rehabilitation 1" and "Rehabilitation 3" precedes "Rehabilitation 4."

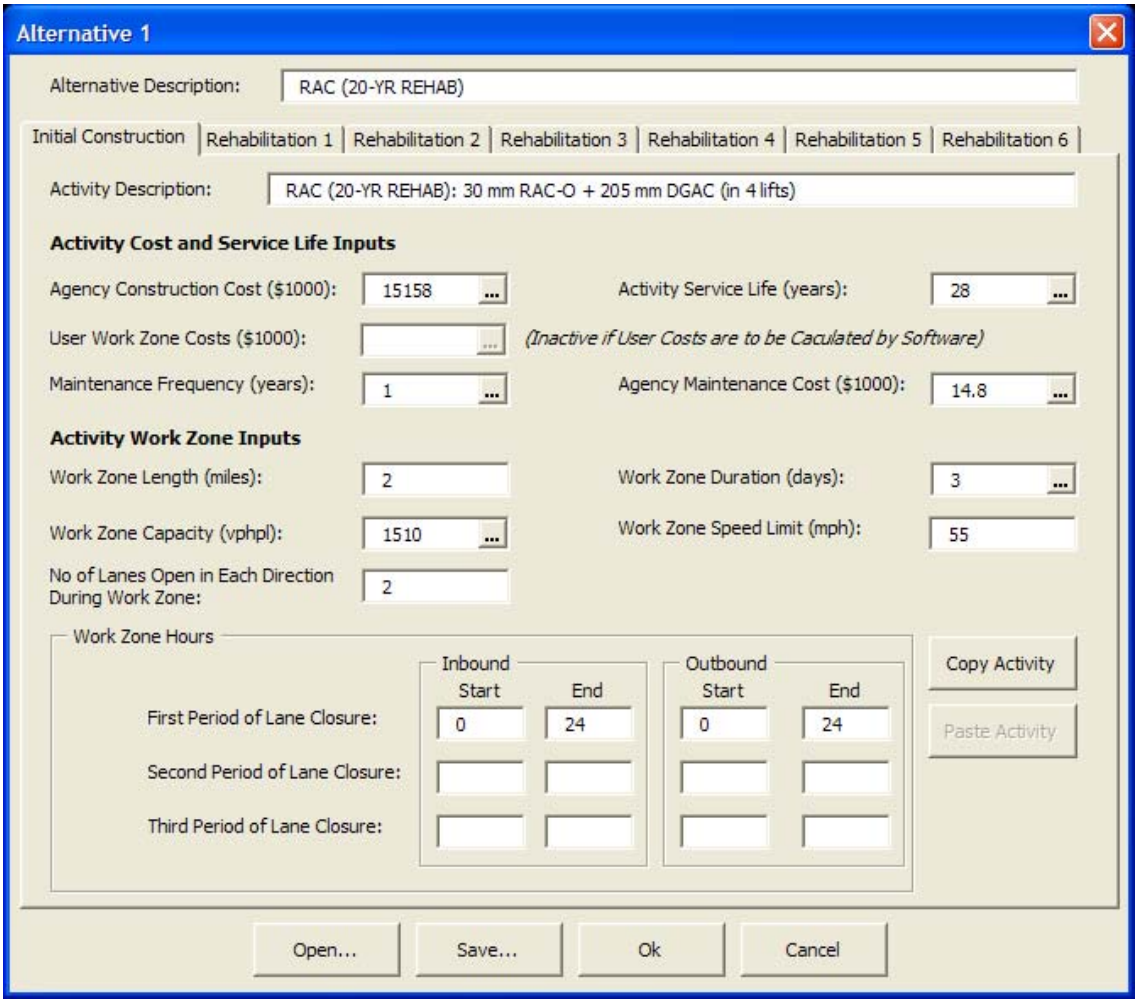


Figure 10. Alternative 1 Form (Which is Identical to the Alternative 2 Form)

The data inputs required under each activity tab on the form are described below.

- *Alternative Description*: Enter a description for a project alternative. For example, "ACOL Overlay (5-YR CapM)" or "HMA Mill & Replace (10-YR Rehab)."
- *Activity Description*: Enter a description for initial construction or future rehabilitation activities being considered for each project alternative.

- *Agency Construction Cost ($1000)*: Under the "Initial Construction" tab, enter the total initial costs in thousands of dollars (engineer's estimate plus project support costs) for a project alternative (as discussed in Section 3.5.1, "Initial Costs"). For future rehabilitation activities to be implemented after the initial construction (i.e., project alternative), enter the total rehabilitation costs in thousands of dollars under the "Rehabilitation" tabs for each future rehabilitation activity (see Section 3.5.3, "Rehabilitation Costs").

- *Activity Service Life (years):* Enter the service life of initial construction (under "Initial Construction" tab) or that of future rehabilitation activity to be followed (under each "Rehabilitation" tab). Refer to Appendix 2 for a pavement M&R schedule applicable for each project alternative and service lives estimated for initial construction and future rehabilitation activities scheduled to be implemented for each project alternative.

- *User Work Zone Costs ($1000):* This field will be inaccessible since the User Cost Computation Method on the "Analysis Options Form" (Figure 5) is set to be "Calculated" as the default.

- *Maintenance Frequency (years):* Refers to the cyclical frequency of interim preventive or corrective maintenance treatments to follow after the initial construction or after each future rehabilitation activity scheduled to be implemented for each project alternative. Enter one (1) year as "Maintenance Frequency," since the annualized cost of these maintenance treatments will be entered as "Agency Maintenance Cost" in the next step.

- *Agency Maintenance Cost ($1000):* As discussed in Section 3.5.2, "Maintenance Costs," this cost includes the costs of preventive or corrective maintenance treatments to preserve or to extend the service life of initial construction or each future rehabilitation activity scheduled to be implemented for each project alternative. It will be calculated by multiplying total number of lane-miles to be treated to the annualized maintenance unit cost ($/lane-mile) of initial construction or of each future rehabilitation activity.

- *Work Zone Length (miles*): This refers to the length in miles of the work zone being considered for initial construction or for each future rehabilitation activity scheduled to be implemented for each project alternative. The work zone length should be based on what is allowed from traffic handling plans, traffic management plans, or historical experience, and it should be measured from the beginning to end of the reduced speed area where the work zone speed limit will be in effect. This information can be obtained from the District TO.

- *Work Zone Duration (days):* This refers to the number of days during which the work zone will be affecting traffic. For example, if the work zone is in effect five days a week for four weeks, the value would be twenty. The estimated work zone duration for initial construction can be obtained from the District Construction. To estimate work zone durations for future rehabilitation activities, refer to Table 11 and Table 12. These tables show estimates of the amount of work (lane-mile per closure) that can be completed under different construction windows and lane closure tactics for typical pavement M&R strategies. Table 11 contains estimates for flexible/rigid pavements and Table 12 contains estimates for rigid pavements only. These production rates are estimated with *CA4PRS* (Construction Analysis for Pavement Rehabilitation Strategies) software, and assume the typical working conditions and resource configurations observed in the past projects. The latest version of *CA4PRS* and its user manual can be obtained from the Division of Research and Innovation (DRI) Web site at http://www.dot.ca.gov/research/roadway/ca4prs/ca4prs.htm.

Table 11. Productivity Estimates of Typical Rehabilitation Strategies for Flexible/Rigid Pavements

Project Type	Strategy Alternative	Description	Lane Closure Tactic (Working Method)	Average Lane-mile Completed Per Closure			
				Weekday Nighttime Closure (10 hour/day Operation)	Weekday Continuous Closure (24 hour/day Operation)	Weekday Continuous Closure (16 hour/day Operation)	Weekend 55-Hour Extended Closure
CapM (5 yr)	HMA Overlay	0.20' DGAC	Two-lane Closure (Single-Lane Paving)	1.2	3.9	2.5	13.2
			Four-lane Closure (Double-lane Paving)	N/A	4.9	3.2	16.8
		0.25' DGAC	Two-lane Closure (Single-Lane Paving)	0.8	3.0	2.0	10.6
			Four-lane Closure (Double-lane Paving)	N/A	3.8	2.6	13.5
	HMA Mill & Replace	Mill & Replace 0.10' OGFC	Two-lane Closure (Single-Lane Paving)	1.3	3.9	2.4	11.9
			Four-lane Closure (Double-lane Paving)	N/A	5.0	3.1	15.2
		Mill 0.10' DGAC and Overlay 0.25' DGAC	Two-lane Closure (Single-Lane Paving)	0.5	2.1	1.4	7.1
			Four-lane Closure (Double-lane Paving)	N/A	2.6	1.8	9.1
	RAC Overlay	0.16' RAC-O	Two-lane Closure (Single-Lane Paving)	1.0	3.3	2.1	11.1
			Four-lane Closure (Double-lane Paving)	N/A	4.2	2.7	14.1
		0.20' RAC-O	Two-lane Closure (Single-Lane Paving)	0.8	2.7	1.8	9.2
			Four-lane Closure (Double-lane Paving)	N/A	3.5	2.2	11.8
Rehab (10 yr)	HMA Overlay	0.44' DGAC (in 2 lifts)	Two-lane Closure (Single-Lane Paving)	0.5	1.7	0.9	5.8
			Four-lane Closure (Double-lane Paving)	N/A	2.2	1.1	7.4
		0.54' DGAC (in 2 lifts)	Two-lane Closure (Single-Lane Paving)	0.1	1.3	0.6	4.8
			Four-lane Closure (Double-lane Paving)	N/A	1.7	0.7	6.1
	HMA Mill & Replace	Mill 0.10' DGAC and Overlay 0.50' DGAC (in 2 lifts)	Two-lane Closure (Single-Lane Paving)	0.1	1.2	0.8	4.2
			Four-lane Closure (Double-lane Paving)	N/A	1.5	0.7	5.4
		Mill 0.35' DGAC and Overlay 0.10' RAC-O + 0.25' DGAC (in 2 lifts)	Two-lane Closure (Single-Lane Paving)	0.2	1.0	0.6	3.1
			Four-lane Closure (Double-lane Paving)	N/A	1.2	0.4	4.0
Rehab (20 yr)	HMA Mill & Replace	Mill 0.64' DGAC and Overlay 0.10' RAC-O + 0.54' DGAC (in 3 lifts)	Two-lane Closure (Single-Lane Paving)	N/A	0.6	0.2	1.8
			Four-lane Closure (Double-lane Paving)	N/A	0.7	0.3	2.2
Rehab (40 yr)	HMA Overlay on Rigid Pvmt	0.10' RAC-O + 0.67' DGAC (in 4 lifts)	Two-lane Closure (Single-Lane Paving)	N/A	0.3	N/A	3.1
			Four-lane Closure (Double-lane Paving)	N/A	0.4	N/A	4.0

Table 12. Productivity Estimates of Typical Rehabilitation Strategies for Rigid Pavements Only

Strategy Type	Strategy Alternative	Description	Lane Closure Tactic (Working Method)	Average Lane-mile Completed Per Closure			
				Weekday Partial Closure (10 hour/day Operation)	Weekday Continuous Closure (24 hour/day Operation)	Weekday Continuous Closure (16 hour/day Operation)	Weekend 55-Hour Extended Closure
CapM (5 yr)	HMA Overlay	0.10' OGFC + 0.15 RAC-O (in 2 lifts)	Two-lane Closure (Single-Lane Paving)	0.9	2.6	1.6	8.6
			Four-lane Closure (Double-lane Paving)	N/A	3.3	2.0	10.8
	Grind Rigid Pvmt	Profile grinding	Two-lane Closure (Single-Lane Paving)	2.3	5.8	3.8	N/A
			Four-lane Closure (Double-lane Paving)	N/A	N/A	N/A	N/A
	Conc Pvmt Rehab	5% slab replacement with profile grinding (0.75' new slab with 4-Hr FSHCC)	Two-lane Closure (Single-Lane Paving)	2.3	5.8	3.8	N/A
			Four-lane Closure (Double-lane Paving)	N/A	N/A	N/A	N/A
		5% slab replacement with profile grinding (0.75' new slab with 12-Hr RSC)	Two-lane Closure (Single-Lane Paving)	0.8	2.2	1.1	7.5
			Four-lane Closure (Double-lane Paving)	N/A	2.9	1.6	9.5
Rehab (10 yr)	HMA Overlay	0.10' OGFC + 0.25' DGAC (in 2 lifts)	Two-lane Closure (Single-Lane Paving)	0.8	2.2	1.1	7.5
			Four-lane Closure (Double-lane Paving)	N/A	2.9	1.6	9.5
Rehab (20 yr)	PCC OVERLAY	0.67' new slab + 0.08' DGAC interlayer (with 12-Hr RSC)	Two-lane Closure (Single-Lane Paving)	N/A	0.26	0.07	0.91
			Four-lane Closure (Double-lane Paving)	N/A	0.34	0.09	1.17
Rehab (40 yr)	Lane Replacement	Lane replacement with profile grinding (0.95' mm new slab with 12-Hr RSC + 0.49' new treated AC base)	Two-lane Closure (Single-Lane Paving)	N/A	0.14	0.04	0.48
			Four-lane Closure (Double-lane Paving)	N/A	0.18	0.04	0.62

- *Work Zone Capacity (vphpl):* Enter the vehicular capacity of one lane of the work zone for one hour. Refer to Table 8 in Section 4.1.3, "Traffic Data," for the recommended values for a typical freeway in rural and urban areas.
- *Work Zone Speed Limit (mph):* Enter the speed limit within the work zone. This information can be obtained from the District TO or the Traffic Management Plan (TMP). Refer to Table 8 in Section 4.1.3, "Traffic Data," for the recommended values for a typical freeway in rural and urban areas.
- *No of Lanes Open in Each Direction During Work Zone:* Enter the number of lanes to be open when the work zone is in effect. The number of lanes to be open applies to each direction. This information can be obtained from the District TO or the TMP.
- *Work Zone Hours:* Enter the work zone hours (using a twenty-four-hour clock) during which the work zone is in effect. Work zone timing can be modeled separately for

inbound and outbound traffic for up to three separate periods for each day. During these hours, road capacity is limited to the work zone capacity. Work zone hours can be obtained from the District TO or the TMP.

Once you have entered all the alternative-level inputs to the Alternative 1 or Alternative 2 forms, click the "Ok" button to return to the Switchboard or "Cancel" button to start over.

(*Note:* Make sure to provide the minimal information in all six "Rehabilitation" tabs to avoid an error message. *No. of Lanes Open in Each Direction during Work Zone*, *Activity Service Life*, *Work Zone Length, Work Zone Speed Limit*, and *Work Zone Capacity* are the minimal inputs required; zero can be entered in the remaining input fields.)

4.3 Input Warnings

To see a list of missing or potentially erroneous data, click the "Show Warnings" button in the Switchboard to have *RealCost* identify and display a list of potential problems (Figure 11). It is recommended that you verify your inputs by clicking this button before running the analysis.

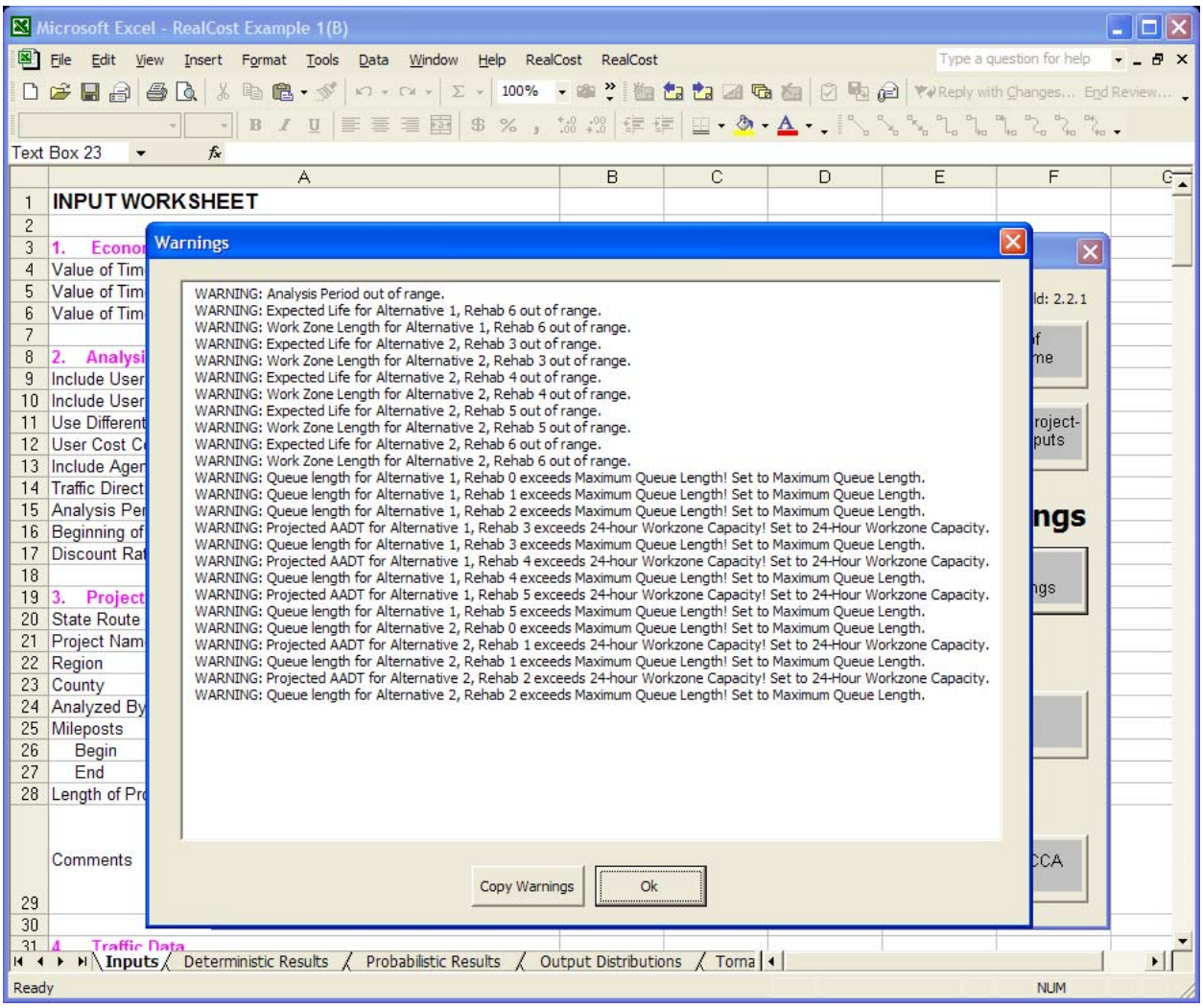


Figure 11. Input Warnings

4.4 Simulation and Outputs

The "Simulation and Outputs" section of the Switchboard includes buttons to view deterministic life-cycle cost results and buttons to run simulations of probabilistic inputs.

- *Deterministic Results:* Click this button to have *RealCost* calculate and display deterministic PV or EUAC for both agency and user costs based upon the deterministic inputs. The "Deterministic Results Form" (Figure 12) provides a direct link ("Go to Worksheet" button) to the "Deterministic Results *Excel* Worksheet" that contains all the information needed to investigate the deterministic results.

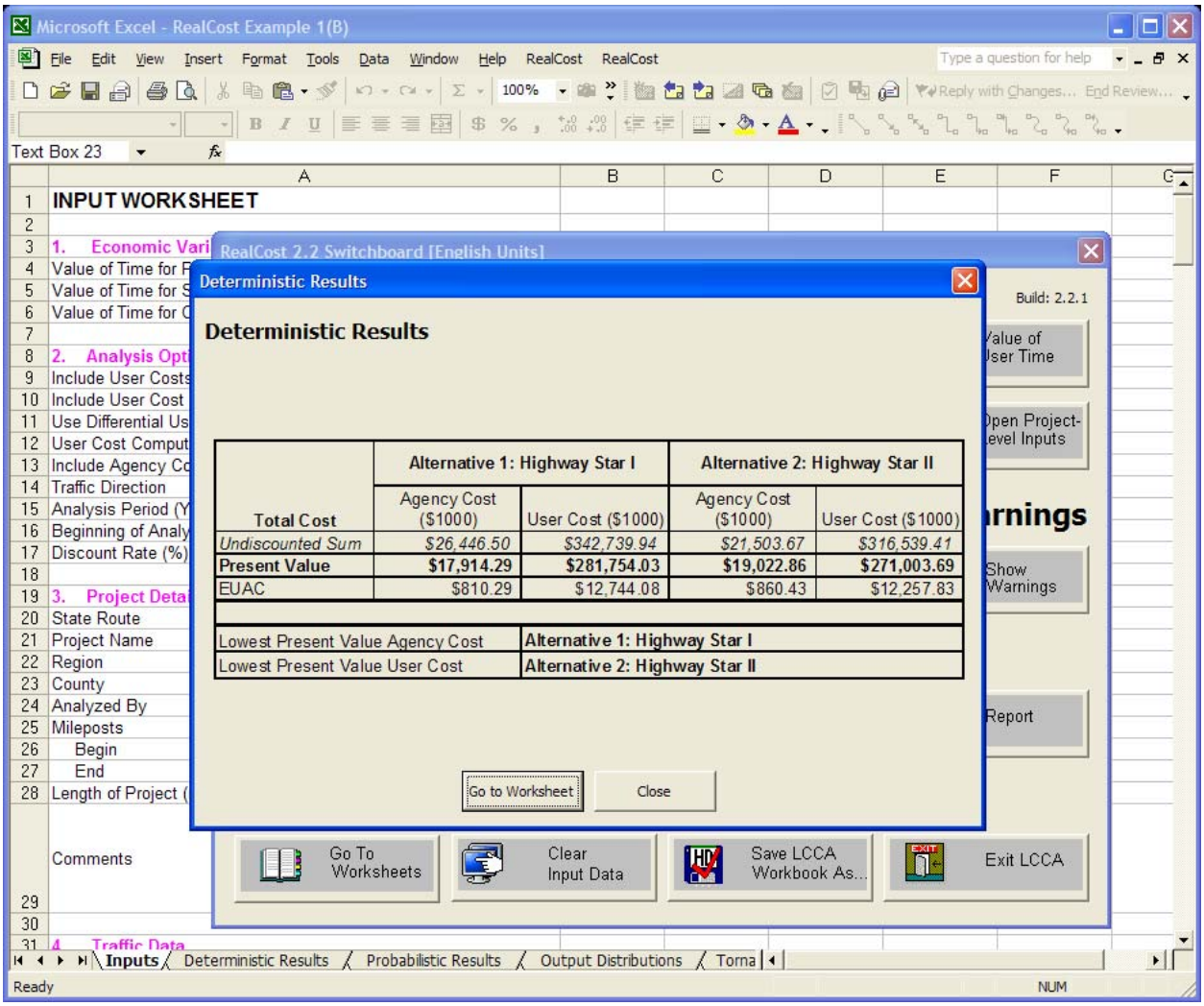


Figure 12. Deterministic Results Form

- *Simulation*: Clicking this button will initiate Monte Carlo simulation of probabilistic inputs. At present it is not being used.
- *Probabilistic Results*: Clicking this button will display probabilistic results. At present it is not being used.
- *Reports*: Click this button to have *RealCost* produce a twelve-page report (Figure 13) that shows inputs and results. The last two pages include results of the probabilistic analysis, and they will be blank if no probabilistic inputs are entered.

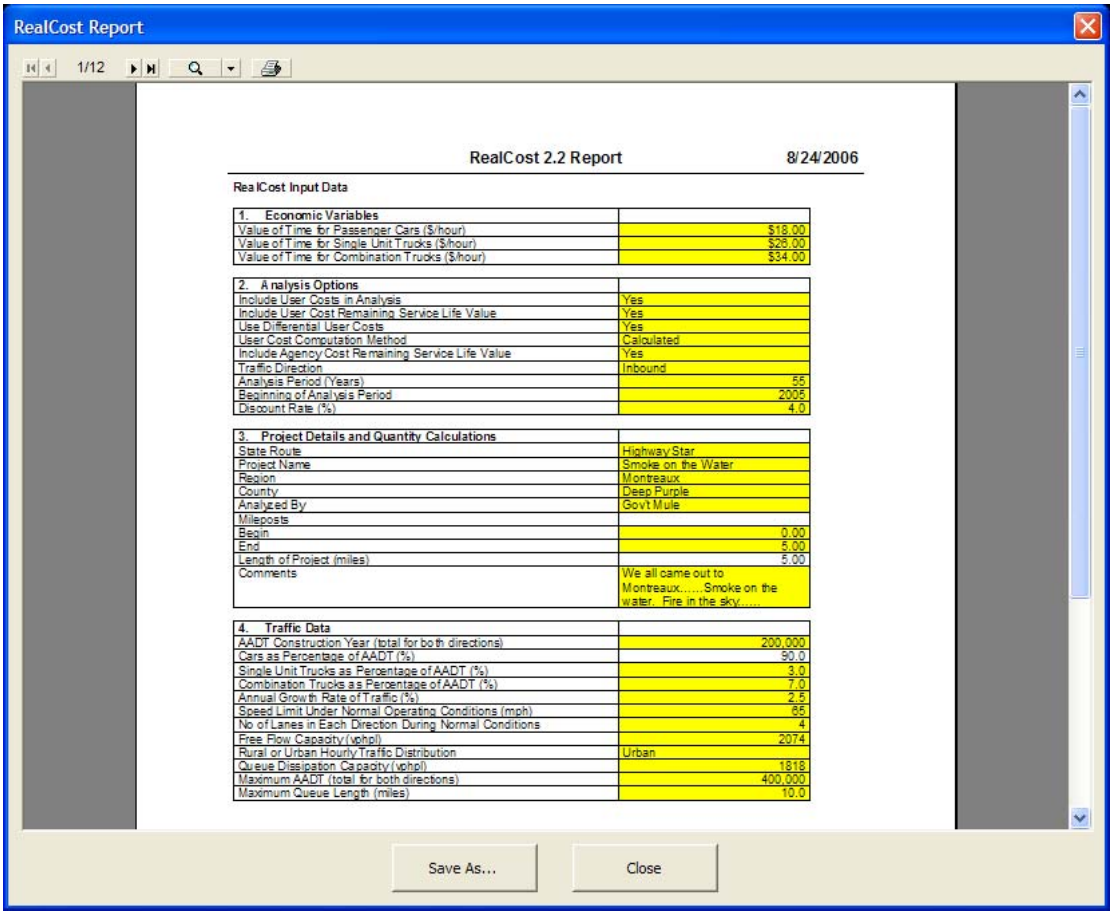


Figure 13. *RealCost* Report

4.5 Administrative Functions

The "Administrative Functions" section of the Switchboard allows the user to save, clear, and retrieve data, and to close the Switchboard or *RealCost*.

- *Go to Worksheets*: Clicking this button will allow direct access to any input or result worksheets.
- *Clear Input Data:* Clicking this button will clear from the software project-level inputs, alternative-level inputs, and results.
- *Save LCCA Workbook As..:* Clicking this button allows you to save the entire *Excel* workbook, including all inputs and results worksheets, under a name you specify.
- *Exit LCCA:* Clicking this button will close *RealCost.*

5.0 EXAMPLES OF LCCA

5.1 Example One

This is a hypothetical project that involves the removal of an existing rigid pavement and its replacement with either a new flexible or rigid pavement. The roadway has four lanes in each direction with 6-feet wide right and left shoulders. The following is the short description of the project.

5.1.1 Alternative 1: Full-Depth AC Replacement (40-year Rehabilitation)

Alternative 1 is a forty-year rehabilitation that involves removal of existing concrete slabs (12-inch) and cement-treated base (6.5-inch) and their replacement with AC (12-inch) on top of AC base (6.5-inch).

a. Initial construction cost is estimated at $12,686,000.
b. Future CapM's: 2-inch HMA Overlay ($2,777,000) or 2-inch HMA mill and replace ($3,409,000) alternating every 9.3 years.
c. No in-between maintenance is assumed.

5.1.2 Alternative 2: Lane Replacement (40-year Rehabilitation)

Alternative 2 is also a forty-year rehabilitation involving removal of both existing concrete slabs (12-inch) and cement-treated base (6.5-inch) and replacement with new concrete slabs (12-inch) on top of AC base (6.5-inch).

a. Initial construction cost is estimated at $18,249,000.
b. Future rehabilitations: random slab replacements with grinding and joint resealing ($2,441,000) every fifteen years.
c. No in-between maintenance is assumed.

Figure 14 shows a typical cross section of the project alternatives.

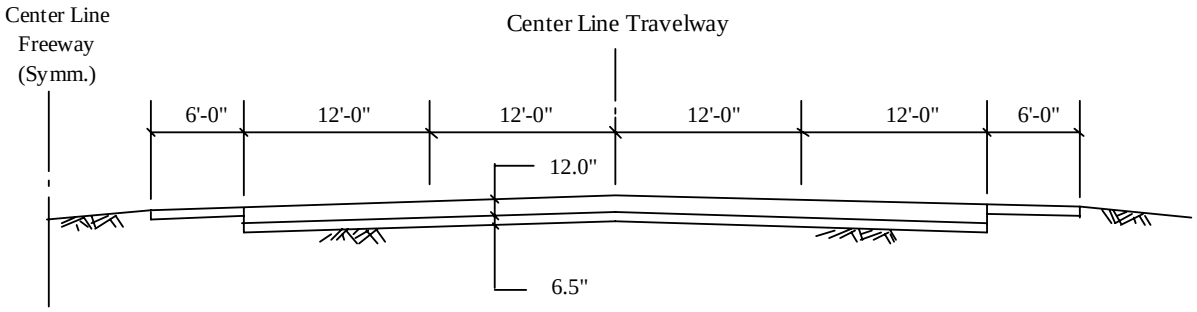
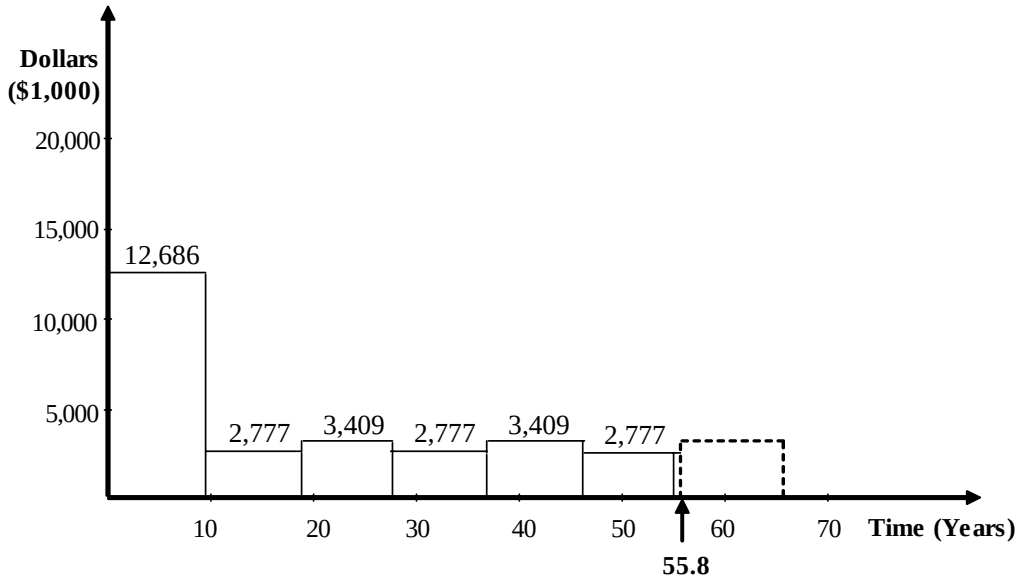
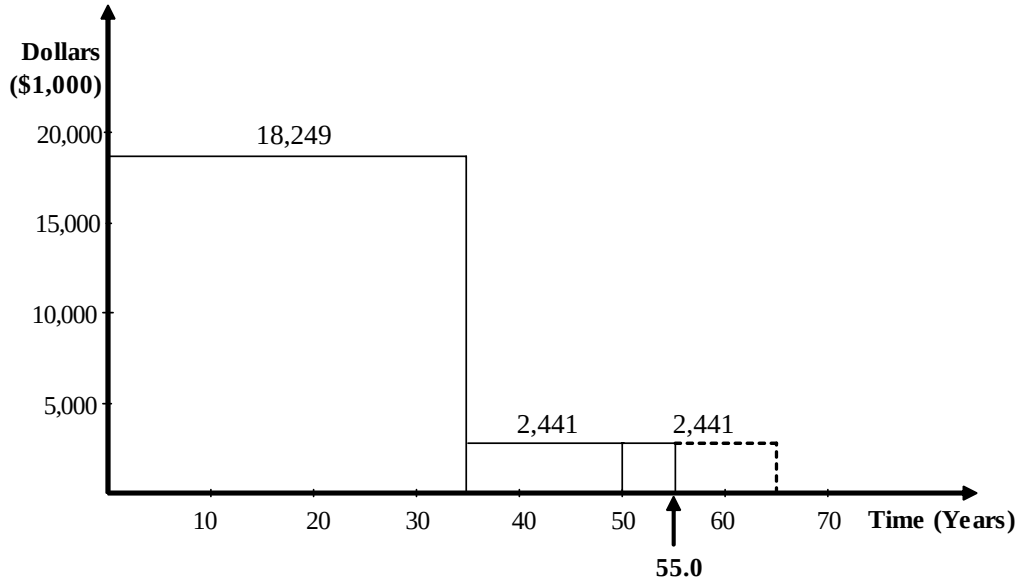


Figure 14. Typical Cross Section of Project Alternatives (Example One)

Figure 15 shows the costs of initial construction/future rehabilitations vs. time for Alternatives 1 and 2, respectively. It is recommended that the cost-versus-time diagrams of competing alternatives are drawn to help visualize the analysis.



Alternative 1



Alternative 2

Figure 15. Cost vs. Time Diagrams of Project Alternatives (Example One)

5.1.3 Results of the Example

Figure 16 shows the first page of the twelve-page report. As noted earlier, you only need to print the first ten pages of the page report. **Error! Reference source not found.** Figure 17 shows the tenth page with the deterministic results of the two alternatives.

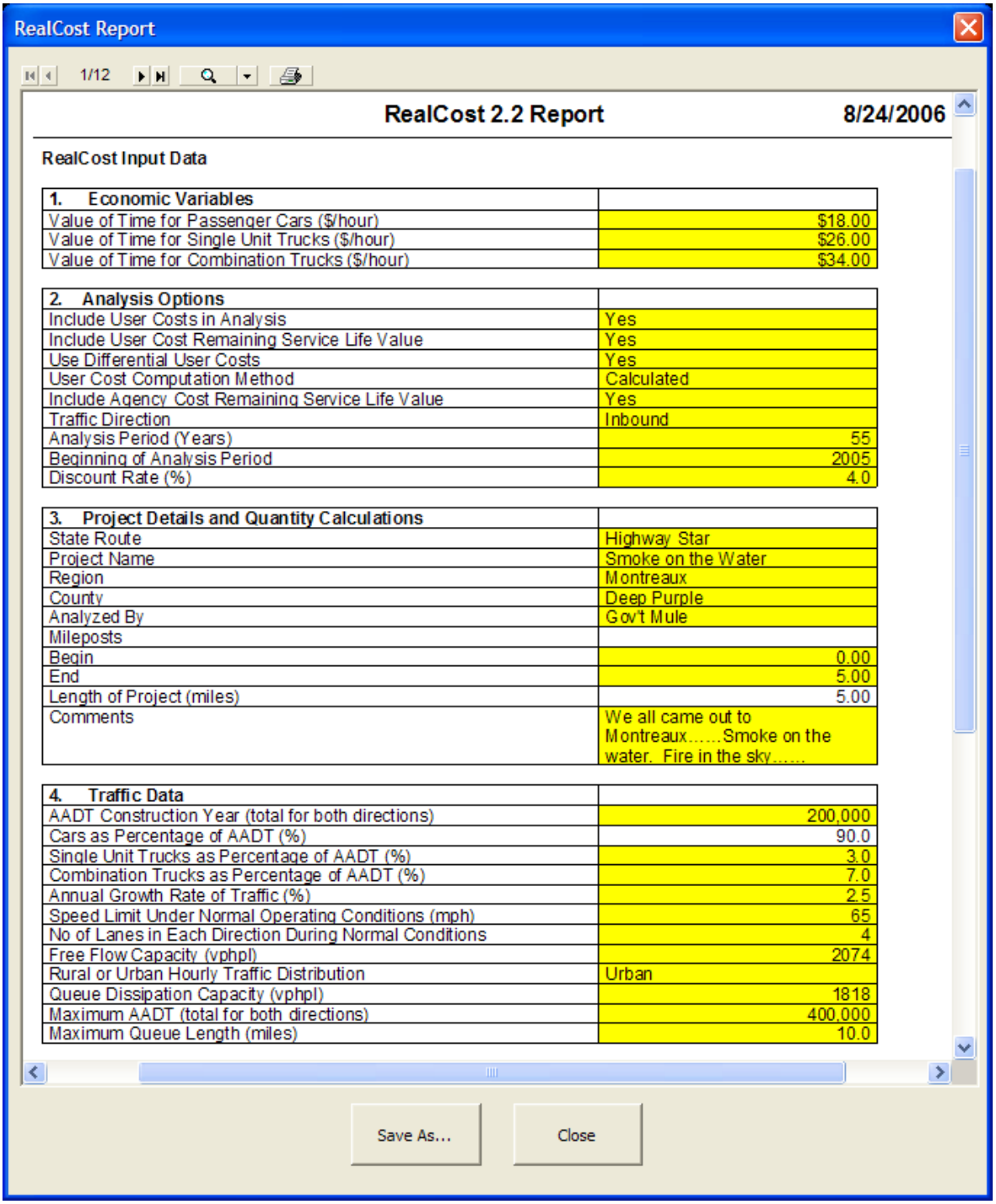


Figure 16. *RealCost* Report (Example One)

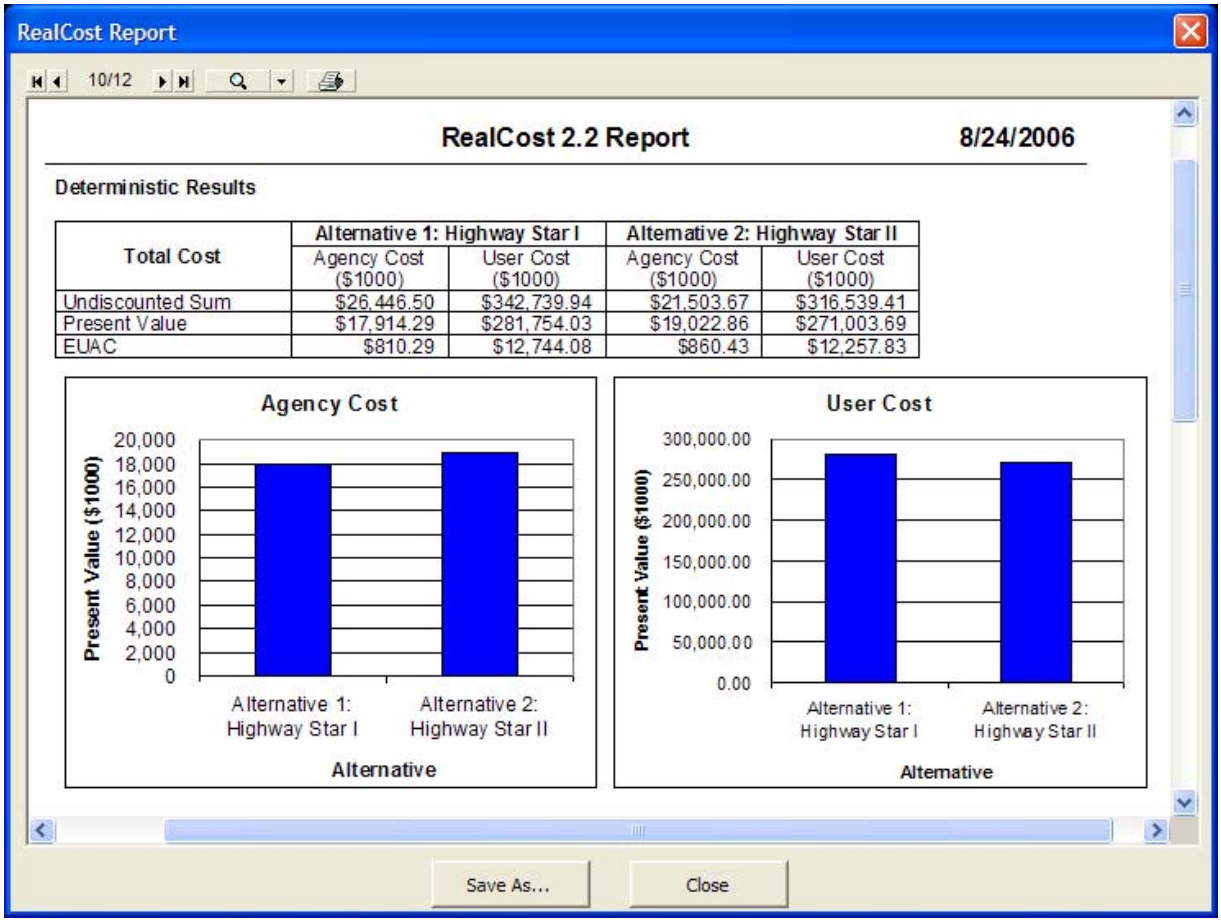


Figure 17. *RealCost* Deterministic Results (Example One)

As the results show, the PV and EUAC of the agency costs for Alternative 1 are less than those for Alternative 2: $17,914,290 (PV #1) and $810,290 (EUAC #1) vs. $19,022,860 (PV #2) and $860,430 (EUAC #2), respectively. However, the PV and EUAC of the user costs for Alternative 1 are higher than those for Alternative 2: $281,754,030 (PV #1) and $12,744,080 (EUAC #1) versus $271,003,690 (PV #2) and $12,257,830 (EUAC #2), respectively.

Comparison of the results shows that the agency cost for Alternative 1 is 6.19 percent less than it is for Alternative 2, while the user cost for Alternative 1 is 3.97 percent more than it is for Alternative 2. Since the difference between the alternatives is within 10 percent, either alternative would be appropriate. When choosing a preferred alternative, other factors (such as

safety and air pollution, and non-user and business impacts resulting from reduced or restricted traffic) should be considered.

5.2 Example Two

This example was an actual project with two lanes in each direction, but some of the information has been modified for a fair comparison. The following is the short description of the project.

a. Project length is 10 miles.
b. AADT in the construction year is 20,000 for both directions.
c. Single-unit trucks as a percentage of AADT is 17 percent.
d. Combination trucks as a percentage of AADT is 16 percent.
e. Maximum AADT is 100,000 for both directions.

5.2.1 Alternative 1: HMA Mill and Replace (5-year CapM)

Alternative 1 is a five-year CapM, which involves milling 1-inch of the existing pavement and replacing it with 1-inch of RAC-G.

a. Initial construction cost is estimated at $5,035,380.
b. No in-between maintenance is assumed.

5.2.2 Alternative 2: HMA Mill and Replace (10-year CapM)

Alternative 2 is a 10-year CapM, which involves milling 2-inch of the existing pavement and replacing it with 2-inch of RAC-G.

a. Initial construction cost is estimated at $7,709,390.
b. Maintenance cost is estimated at $200,000 for every 5 years (EUAC of $44,925).

Figure 18 shows a typical cross section of the existing pavement.

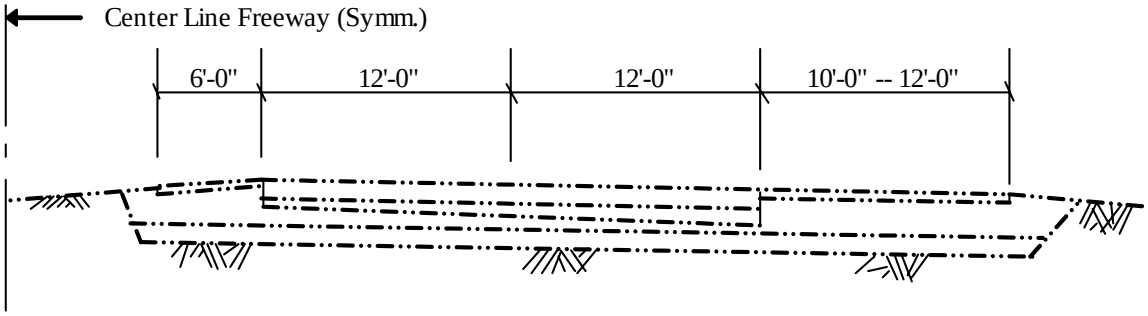
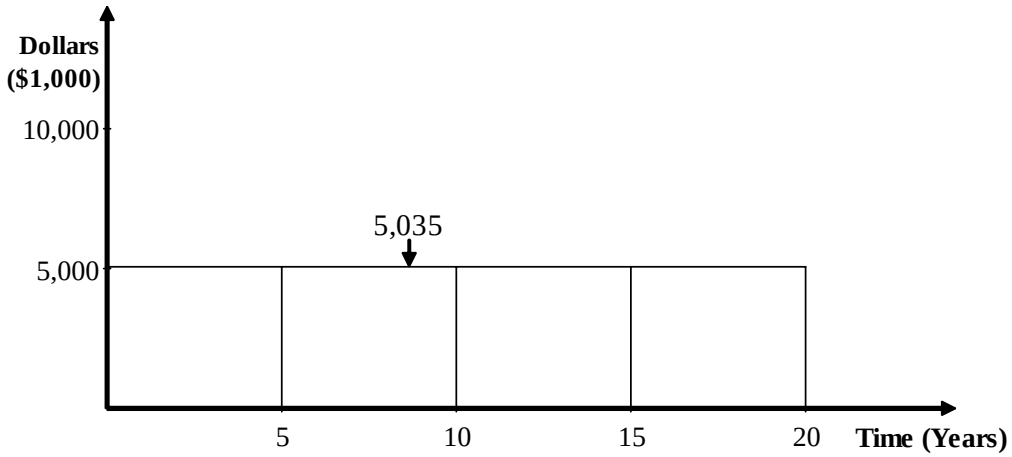
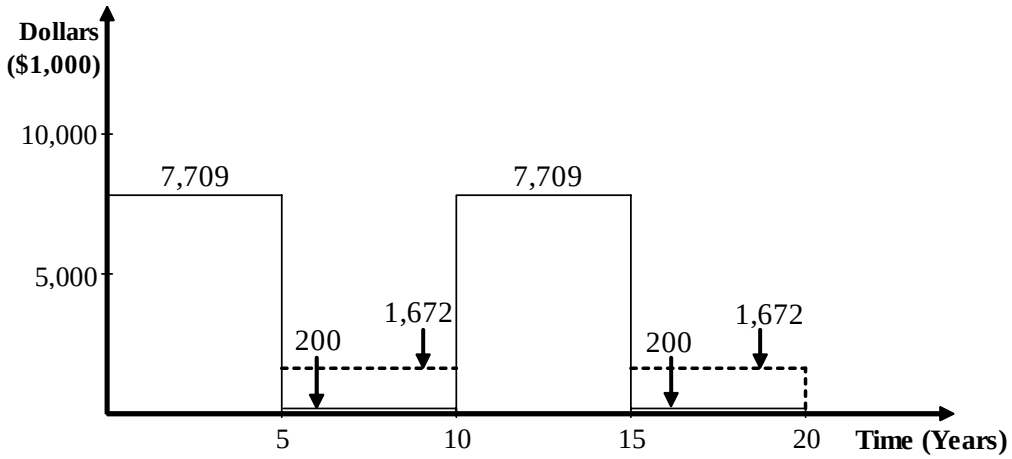


Figure 18. Existing Typical Cross Section (Example Two)

Figure 19 shows the cost-versus-time diagrams for Alternatives 1 and 2, respectively.



Alternative 1

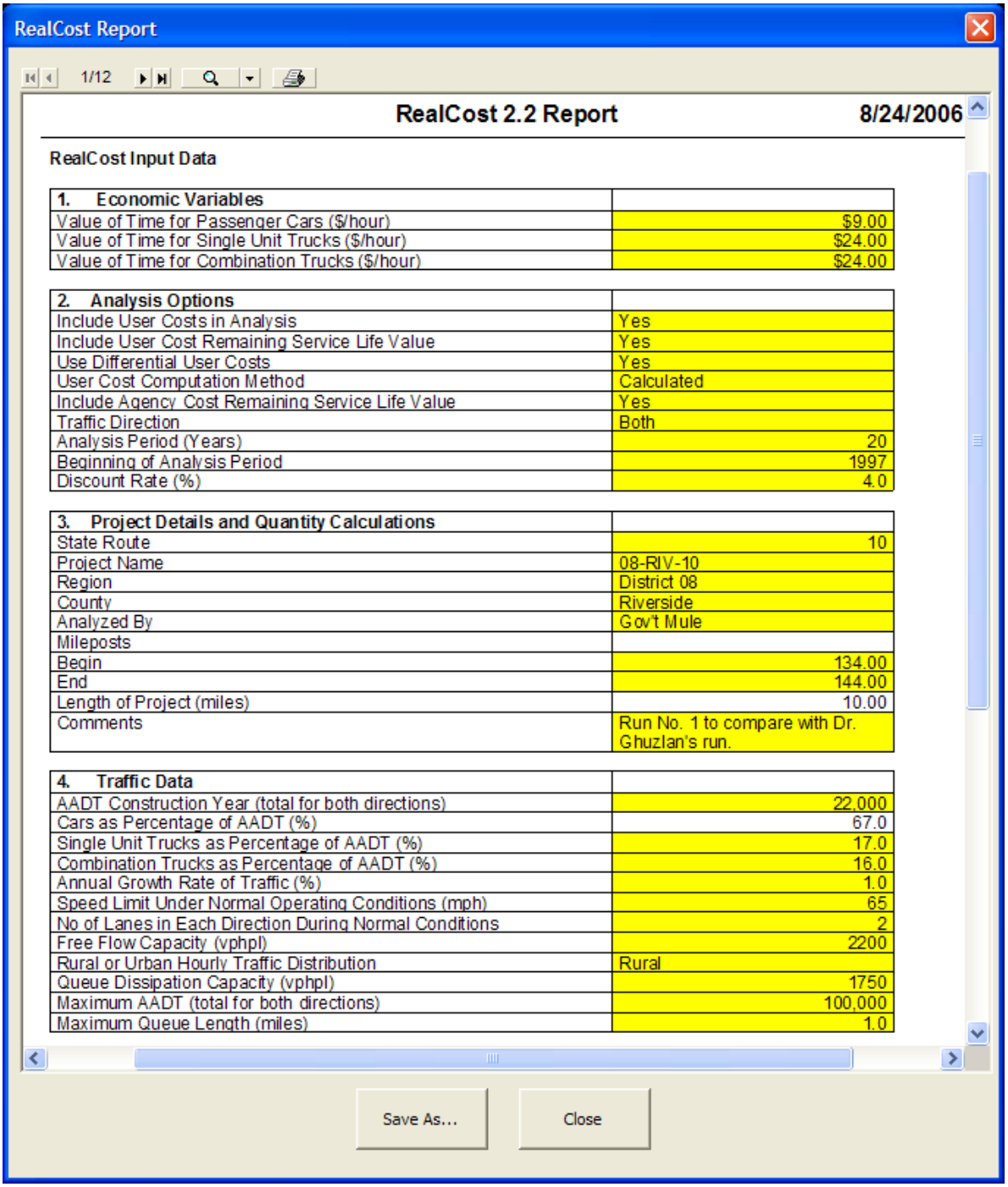


Alternative 2

Figure 19. Cost vs. Time Diagrams of Project Alternatives (Example Two)

5.2.3 Results of the Example

Figure 20 shows the first page of the report and Figure 21 shows results of the deterministic analysis.



1. Economic Variables	
Value of Time for Passenger Cars ($/hour)	$9.00
Value of Time for Single Unit Trucks ($/hour)	$24.00
Value of Time for Combination Trucks ($/hour)	$24.00

2. Analysis Options	
Include User Costs in Analysis	Yes
Include User Cost Remaining Service Life Value	Yes
Use Differential User Costs	Yes
User Cost Computation Method	Calculated
Include Agency Cost Remaining Service Life Value	Yes
Traffic Direction	Both
Analysis Period (Years)	20
Beginning of Analysis Period	1997
Discount Rate (%)	4.0

3. Project Details and Quantity Calculations	
State Route	10
Project Name	08-RIV-10
Region	District 08
County	Riverside
Analyzed By	Gov't Mule
Mileposts	
Begin	134.00
End	144.00
Length of Project (miles)	10.00
Comments	Run No. 1 to compare with Dr. Ghuzlan's run.

4. Traffic Data	
AADT Construction Year (total for both directions)	22,000
Cars as Percentage of AADT (%)	67.0
Single Unit Trucks as Percentage of AADT (%)	17.0
Combination Trucks as Percentage of AADT (%)	16.0
Annual Growth Rate of Traffic (%)	1.0
Speed Limit Under Normal Operating Conditions (mph)	65
No of Lanes in Each Direction During Normal Conditions	2
Free Flow Capacity (vphpl)	2200
Rural or Urban Hourly Traffic Distribution	Rural
Queue Dissipation Capacity (vphpl)	1750
Maximum AADT (total for both directions)	100,000
Maximum Queue Length (miles)	1.0

Figure 20. *RealCost* Report (Example Two)

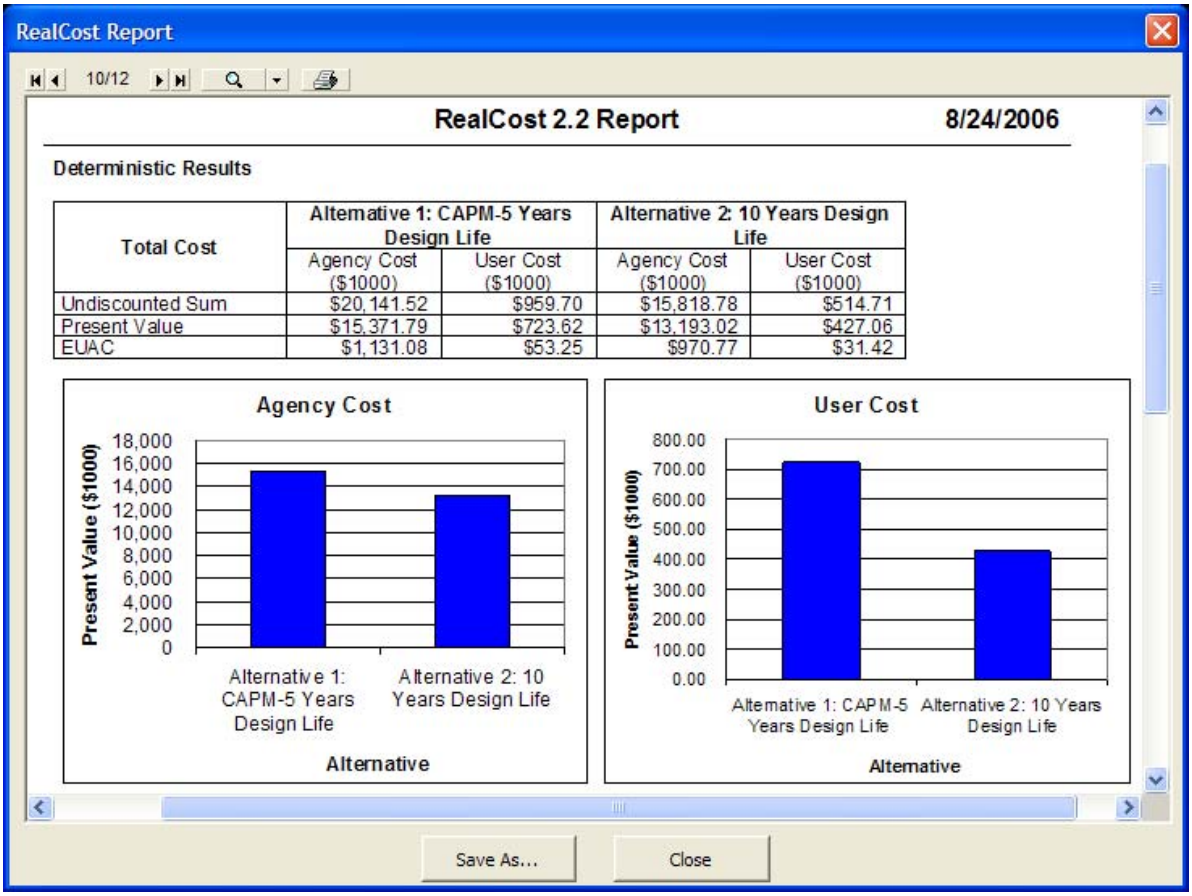


Figure 21. *RealCost* Deterministic Results 1 (Example Two)

Comparison of the results shows that the agency cost for Alternative 2 is 16.5 percent less than it is for Alternative 1. The user cost for Alternative 2 is also substantially less than it is for Alternative 1 (69.5 percent less). Therefore, Alternative 2 is the better option.

Figure 22 shows the results of a what-if scenario in which the maintenance cost of Alternative 2 is increased to $1,672,000 for every five-year period (EUAC of $375,577). Under this scenario, the agency costs of the alternatives are fairly close (within 10 percent), but the user cost of Alternative 2 is still much less than it is for Alternative 1 since the traffic information was not changed. Therefore, Alternative 2 is still the better option, assuming everything else is equal for the alternatives.

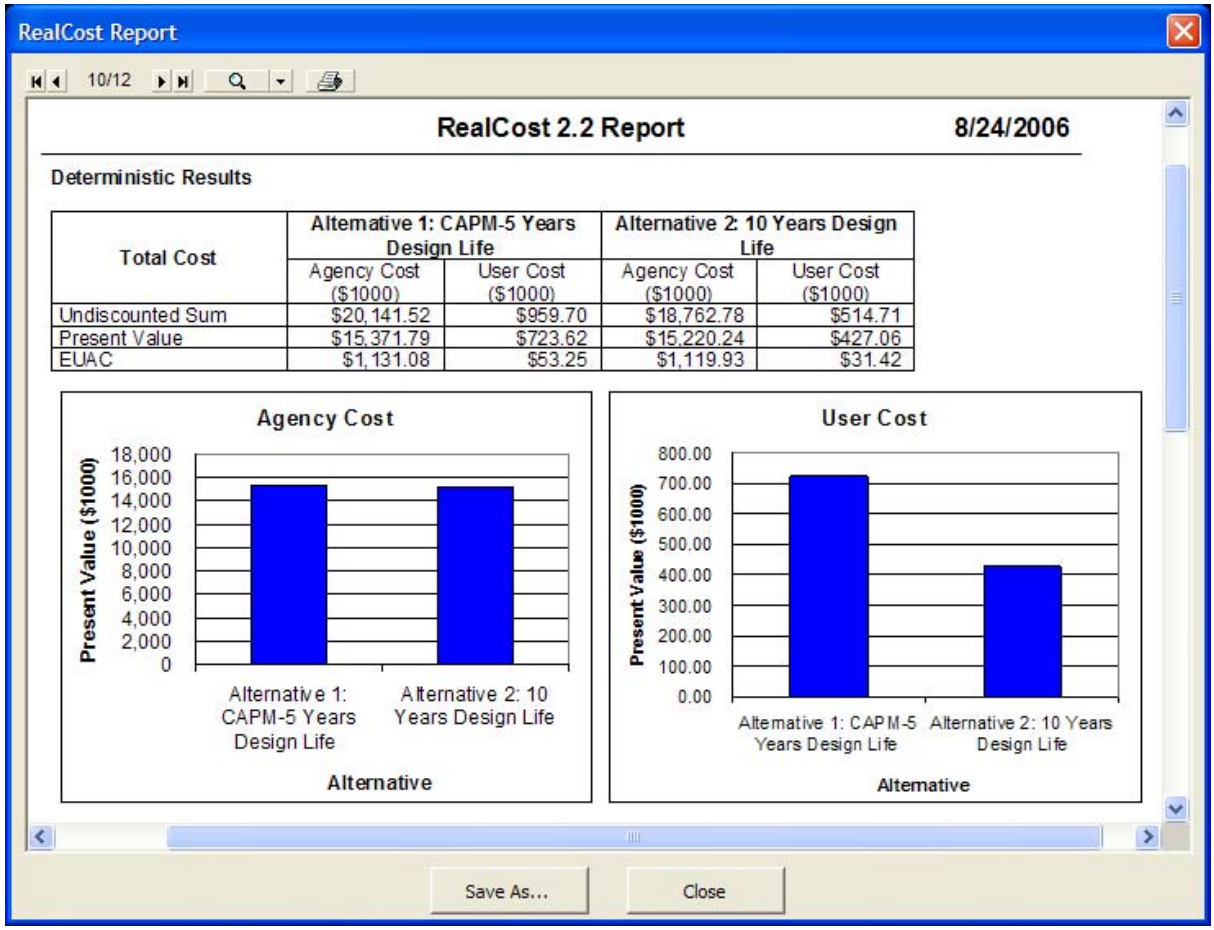


Figure 22. *RealCost* Deterministic Results 2 (Example Two)

REFERENCES

1. Federal Highway Administration, "Life-Cycle Cost Analysis in Pavement Design," FHWA-SA-98-079, Pavement Division Interim Technical Bulletin, September 1998.

2. Life-Cycle Cost Analysis, *RealCost* User Manual, August 2004.

3. California Department of Transportation, "2004 State of the Pavement," Division of Maintenance, Office of Roadway Rehabilitation and Roadway Maintenance, July 2005.

4. California Department of Transportation, "HM-1 Major Maintenance Contracts 2004/05 Fiscal Year-End Report," Division of Maintenance, Office of Roadway Maintenance, September 2005.

5. California Department of Transportation, "Highway Design Manual," Fifth Edition, July 2004 with December 2004 Addendum.

6. California Department of Transportation, "Historical Cost Analysis of Capital Outlay Support for FYs 1998 to 2002," Division of Project Management, Office of Project Workload and Data Management, May 2005.

7. Washington State Department of Transportation, "Pavement Type Selection Protocol," Environmental and Engineering Program Division, January 2005.

APPENDIX 1: LIST OF LIMITATIONS TO AND BUGS IN *REALCOST*

Bug/Question(s)

1. Program appears to calculate salvage value based on a round-down if activity life is in decimal of less than 0.5 year (see Example I).

Limitation(s)

1. Analysis period input has a range of up to forty years.
2. *RealCost* only allows for up to six subsequent maintenance/rehabilitation actions in an alternative life cycle path.

APPENDIX 2: TYPICAL PAVEMENT M&R SCHEDULES FOR CALIFORNIA

The following pavement M&R schedules are a consolidation of the "Pavement M&R Decision Trees" (for pavement M&R activity scheduling) included in Caltrans district offices' ten-year pavement plans. Currently, each Caltrans district office has its own set of pavement decision trees, most of which have different sequences of pavement M&R activities, depending on route class (alternatively known maintenance service level) and pavement type. The following compilation of California-specific pavement M&R schedules has been developed to simplify the selection of a pavement M&R schedule for the LCCA.

The categorization of these California-specific pavement M&R schedules is based on four factors: the climate region, maintenance service level, existing pavement/final surface type, and initial M&R strategy (i.e., project alternatives).

The nine climate regions designated in the "Map of Caltrans Climate Regions" (see Figure 23) are grouped into the five climate regions (i.e., Coastal, Inland Valley, High Mountain & High Desert, Desert and Low Mountain & South Mountain; see Table 13), and the pavement M&R decisions applicable to these five climate regions are collected from the district offices.

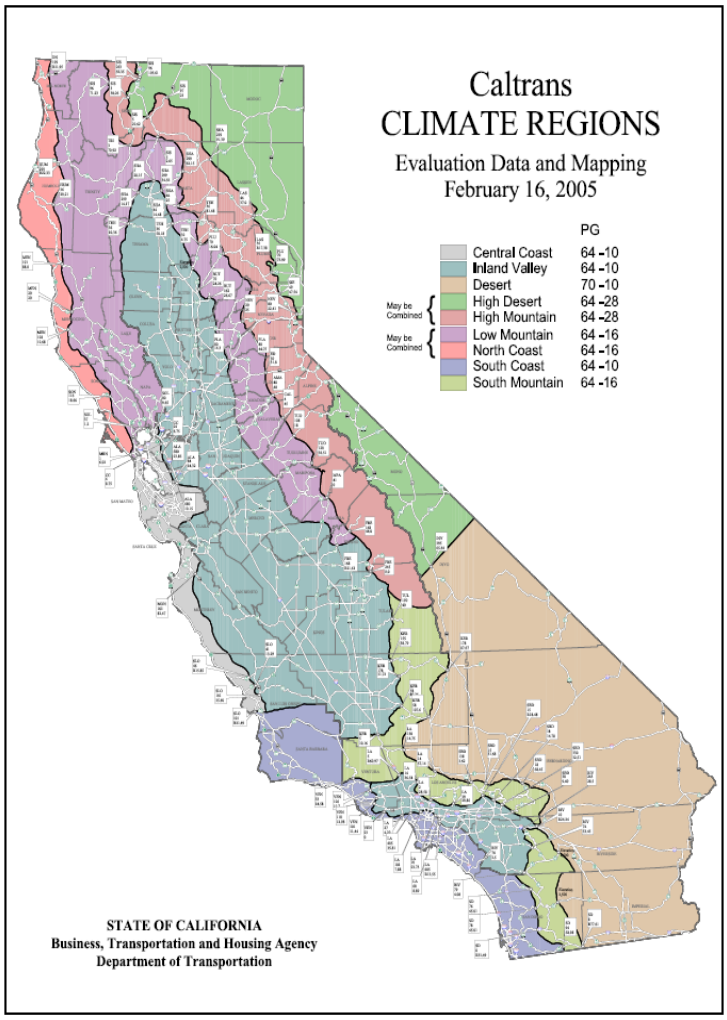


Figure 23. Map of Caltrans Climate Regions

Table 13. Caltrans Climate Region Classification

Caltrans Climate Regions	Climate Regions for Pavement M&R Schedules
North Coast	Coastal
Central Coast	
South Coast	
Inland Valley	Inland Valley
High Mountain	High Mountain and High Desert
High Desert	
Desert	Desert
Low Mountain	Low Mountain and South Mountain
South Mountain	

If a pavement decision tree for a particular pavement type is not available for a particular climate region, a similar decision tree from another region is used instead. Since the majority of the district offices do not currently have a pavement decision tree for "New" and "Reconstructed" pavements, the pavement M&R activity sequence and service lives presented for these types of pavements are based on engineering judgment and experience.

Note: These pavement M&R schedules assume there will be no early failures due to non-conformance to the specified mix design or poor construction quality.

Table F1-1 (1)
Hot Mixed Asphalt Pavement Maintenance & Rehabilitation Schedule
New Construction/Reconstruction, All Coastal Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
New Construction/Reconstruction																
HMA	20	1,2	1	Year of Action	0				20	25		35	40		50	
				Activity Description	New Const./ Reconst. (20 yr)				CapM (5 yr)	Rehab (10 yr)		CapM (5 yr)	Rehab (10 yr)		CapM (5 yr)	
				Activity Service Life (years)	20				5	10		5	10		5	
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	1,167				1,139	2657		1,139	2,657		1,139	
			2	Year of Action	0				20	25				45	50	
				Activity Description	New Const./ Reconst. (20 yr)				CapM (5 yr)	Rehab (20 yr)				CapM (5 yr)	Rehab (20 yr)	
				Activity Service Life (years)	20				5	20				5	20	
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	1,167				1,139	1,199				1,139	1,167	
		3		Year of Action	0				20		30		40	45		
				Activity Description	New Const./ Reconst. (20 yr)				CapM (5 yr)		CapM (5 yr)		CapM (5 yr)	Reconstruct (20 yr)		
				Activity Service Life (years)	20				10		10		5	20		
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	1,167				2,675		2,675		1,096			
HMA w/ OGFC	20	1,2	1	Year of Action	0				22		32			45		55
				Activity Description	New Const./ Reconst. (20 yr)				CapM w/ OGFC (5 yr)		Rehab w/ OGFC (10 yr)			CapM w/ OGFC (5 yr)		Rehab w/ OGFC (10 yr)
				Activity Service Life (years)	22				10		13			10		13
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	1,478				3,464		2,502			3,464		2,502
			2	Year of Action	0				22		32				53	
				Activity Description	New Const./ Reconst. (20 yr)				CapM w/ OGFC (5 yr)		Rehab w/ OGFC (20 yr)				CapM w/ OGFC (5 yr)	
				Activity Service Life (years)	22				10		21				10	
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	1,478				3,464		1,522				3,464	
		3		Year of Action	0				22		32		42		52	
				Activity Description	New Const./ Reconst. (20 yr)				CapM w/ OGFC (5 yr)		CapM w/ OGFC (5 yr)		CapM w/ OGFC (5 yr)		Reconstruct (20 yr)	
				Activity Service Life (years)	22				10		10		10		22	
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	1,478				3,464		3,464		3,464		1,478	
	40	1,2		Year of Action	0								40		50	
				Activity Description	New Const./ Reconst. (40 yr)								CapM w/ OGFC (5 yr)		Rehab w/ OGFC (20 yr)	
				Activity Service Life (years)	40								10		21	
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	2,921								3,464		1,522	
		3		Year of Action	0								40		50	
				Activity Description	New Const./ Reconst. (40 yr)								CapM w/ OGFC (5 yr)		CapM w/ OGFC (5 yr)	
				Activity Service Life (years)	40								10		10	
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	2,921								3,464		3,464	

Table F1-1 (2)
Hot Mixed Asphalt Pavement Maintenance & Rehabilitation Schedule

CapM, All Coastal Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
CapM																
HMA	5	1,2		Year of Action	0	5		15	20							
				Activity Description	CapM (5 yr)	Rehab (10 yr)		CapM (5 yr)	Rehab (10 yr)							
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	5 / 1,096	10 / 2,675		5 / 1,096	10 / 2,675							
		3		Year of Action	0	5		15								
				Activity Description	CapM (5 yr)	CapM (5 yr)		CapM (5 yr)								
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	5 / 1,096	10 / 2,675		10 / 494								
	10	1,2		Year of Action	0		10				30		40			
				Activity Description	CapM (10 yr)		Rehab (20 yr)				CapM (10 yr)		Rehab (20 yr)			
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 2,675		20 / 1,199				10 / 2675		20 / 1,199			
		3		Year of Action	0		10		20		30					
				Activity Description	CapM (10 yr)		CapM (10 yr)		CapM (10 yr)		CapM (10 yr)					
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 2,675		10 / 2,675		10 / 2,675		10 / 2,675					
HMA w/ OGFC	5	1,2		Year of Action	0		10			25						
				Activity Description	CapM w/ OGFC (5 yr)		Rehab w/ OGFC (10 yr)			CapM w/ OGFC (5 yr)						
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 3,464		15 / 2,247			10 / 3,464						
		3		Year of Action	0		10		20							
				Activity Description	CapM w/ OGFC (5 yr)		CapM w/ OGFC (5 yr)		CapM w/ OGFC (5 yr)							
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 3,464		10 / 3,464		10 / 3,464							
	10	1,2		Year of Action	0			15				36				
				Activity Description	CapM w/ OGFC (10 yr)			Rehab w/ OGFC (20 yr)				CapM w/ OGFC (10 yr)				
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	15 / 2,247			21 / 1,522				15 / 2,247				
		3		Year of Action	0			15			30					
				Activity Description	CapM w/ OGFC (10 yr)			CapM w/ OGFC (10 yr)			CapM w/ OGFC (10 yr)					
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	15 / 2,247			15 / 2,247			15 / 2,247					

Table F1-1 (3)
Hot Mixed Asphalt Pavement Maintenance & Rehabilitation Schedule
Rehabilitation, All Coastal Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
Rehabilitation																
HMA	10	1,2,3		Year of Action	0	9		15		25		35				
				Activity Description	Rehab (10 yr)	CapM (5 yr)		Rehab (10 yr)		CapM (5 yr)		Rehab (10 yr)				
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	9 / 2,940	6 / 895		10 / 2,675		10 / 2,675		10 / 2,675				
	20	1,2,3		Year of Action	0				20	25				45	50	
				Activity Description	Rehab (20 yr)				CapM (5 yr)	Rehab (20 yr)				CapM (5 yr)	Rehab (20 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	20 / 1,199				5 / 1,096	20 / $1,199				5 / 1,096	20 / 1,199	
HMA w/ OGFC	10	1,2,3		Year of Action	0			15		25			40			
				Activity Description	Rehab w/ OGFC (10 yr)			CapM w/ OGFC (5 yr)		Rehab w/ OGFC (10 yr)			CapM w/ OGFC (5 yr)			
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	15 / 2,247			10 / 3,464		15 / 2,247			10 / 3,464			
	20	1,2,3		Year of Action	0				20		30				50	
				Activity Description	Rehab w/ OGFC (20 yr)				CapM w/ OGFC (5 yr)		Rehab w/ OGFC (20 yr)				CapM w/ OGFC (5 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	20 / 1,699				10 / 3,464		20 / 1,699				10 / 3,464	
	40	1,2,3		Year of Action	0								40		50	
				Activity Description	Rehab w/ OGFC (40 yr)								CapM (5 yr)		Rehab w/ OGFC (40 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	40 / 3,350								10 / 3,436		40 / 3,350	

Table F1-2 (1)
Rubberized Asphalt Concrete Pavement Maintenance & Rehabilitation Schedule
New Construction/Reconstruction, All Coastal Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
New Construction/Reconstruction																
RAC	20	1,2	1	Year of Action	0				20	29		39		48		
				Activity Description	New Const./ Reconst. (20 yr)				RAC CapM (5 yr)	RAC Rehab (10 yr)		RAC CapM (5 yr)		RAC Rehab (10 yr)		
				Activity Service Life (years)	20				9	10		9		10		
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	1,846				4,270	3,915		4,270		3,915		
			2	Year of Action	0				20	29				49		
				Activity Description	New Const./ Reconst. (20 yr)				RAC CapM (5 yr)	RAC Rehab (20 yr)				RAC CapM (5 yr)		
				Activity Service Life (years)	20				9	20				9		
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	1,846				4,270	1,846				4,270		
		3		Year of Action	0				20	29			42			55
				Activity Description	New Const./ Reconst. (20 yr)				RAC CapM (5 yr)	RAC CapM (10 yr)			RAC CapM (10 yr)			Reconst. (20 yr)
				Activity Service Life (years)	20				9	13			13			20
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	1,846				4,270	3,057			3,057			1,167
RAC w/ RAC-O	20	1,2	1													
			2													
		3														
	40	1,2														
		3														

Table F1-2 (2)
Rubberized Asphalt Concrete Pavement Maintenance & Rehabilitation Schedule
CapM, All Coastal Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
CapM																
RAC	5	1,2		Year of Action	0	9		19		29						
				Activity Description	RAC CapM (5 yr)	RAC Rehab (10 yr)		RAC CapM (5 yr)		RAC Rehab (10 yr)						
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	9 / 4,270	10 / 3,915		9 / 4,270		10 / 3,915						
		3		Year of Action	0	9		18		27						
				Activity Description	RAC CapM (5 yr)	RAC CapM (5 yr)		RAC CapM (5 yr)		Reconst. (20 yr)						
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	9 / 4,270	9 / 4,270		9 / 4,270		20 / 1,167						
	10	1,2		Year of Action	0		13					35				
				Activity Description	RAC CapM (10 yr)		RAC Rehab (20 yr)					RAC CapM (10 yr)				
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 3,915		25 / 3,530					10 / 3,915				
		3		Year of Action	0			13	22			35				
				Activity Description	RAC CapM (10 yr)			RAC CapM (5 yr)	RAC CapM (10 yr)			Reconst. (20 yr)				
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	13 / 3,057			9 / 4,270	13 / 3,057			20 / 1,167				
RAC w/ RAC-O	10	1,2														
		3														

Table F1-2 (3)
Rubberized Asphalt Concrete Pavement Maintenance & Rehabilitation Schedule
Rehabilitation, All Coastal Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
Rehabilitation																
RAC	10	1,2,3		Year of Action	0		10	19		29						
				Activity Description	RAC Rehab (10 yr)		RAC CapM (5 yr)	RAC Rehab (10 yr)		RAC CapM (5 yr)						
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 3,915		9 / 4,270	10 / 3,915		9 / 4,270						
	20	1,2,3		Year of Action	0				25		34					
				Activity Description	RAC Rehab (20 yr)				RAC CapM (5 yr)		RAC Rehab (20 yr)					
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	25 / 3,530				9 / 4,270		25 / 3,530					
RAC w/ RAC-O	10	1,2,3														
	20	1,2,3														
	40	1,2,3														

Table F2-1 (1)
Hot Mixed Asphalt Pavement Maintenance & Rehabilitation Schedule
New Construction/Reconstruction, Inland Valley Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
New Construction/Reconstruction																
HMA	20	1,2	1	Year of Action	0			18	23		33	38		48	53	
				Activity Description	New Const./ Reconst. (20 yr)			CapM (5 yr)	Rehab (10 yr)		CapM (5 yr)	Rehab (10 yr)		CapM (5 yr)	Rehab (10 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	18 / 1,252			5 / 1,096	10 / 2,675		5 / 1,096	10 / 2,675		5 / $1,096	10 / 2,675	
			2	Year of Action	0			18	23				41	46		
				Activity Description	New Const./ Reconst. (20 yr)			CapM (5 yr)	Rehab (20 yr)				CapM (5 yr)	Rehab (20 yr)		
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	18 / 1,252			5 / 1,096	18 / 1,252				5 / 1,096	18 / 1,252		
		3		Year of Action	0			18		28		38		43		
				Activity Description	New Const./ Reconst. (20 yr)			CapM (5 yr)		CapM (5 yr)		CapM (5 yr)		Reconst. (20 yr)		
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	18 / 1,252			10 / 2,675		10 / 2,675		5 / 1,096		18 / 1,252		
HMA w/ OGFC	20	1,2	1	Year of Action	0				20		30			45		55
				Activity Description	New Const./ Reconst. (20 yr)				CapM w/ OGFC (5 yr)		Rehab w/ OGFC (10 yr)			CapM w/ OGFC (5 yr)		Rehab w/ OGFC (10 yr)
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	20 / 1,571				10 / 3,464		15 / 2,247			10 / 3,464		15 / 2,247
			2	Year of Action	0				20		30					54
				Activity Description	New Const./ Reconst. (20 yr)				CapM w/ OGFC (5 yr)		Rehab w/ OGFC (20 yr)					CapM w/ OGFC (5 yr)
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	20 / 1,571				10 / 3,464		24 / 2,726					10 / 3,464
		3		Year of Action	0				20		30		40		50	
				Activity Description	New Const./ Reconst. (20 yr)				CapM w/ OGFC (5 yr)		CapM w/ OGFC (5 yr)		CapM w/ OGFC (5 yr)		Reconst. (20 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	20 / 1,571				10 / 3,464		10 / 3,464		10 / 3,464		20 / 1,571	
	40	1,2		Year of Action	0								40		50	
				Activity Description	New Const./ Reconst. (40 yr)								CapM w/ OGFC (5 yr)		Reconst. (20 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	40 / 2,466								10 / 3,464		20 / 1,571	
		3		Year of Action	0								40		50	
				Activity Description	New Const./ Reconst.								CapM w/ OGFC (5 yr)		CapM w/ OGFC (5 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	40 / 2,466								10 / 3,464		10 / 3,464	

Table F2-1 (2)
Hot Mixed Asphalt Pavement Maintenance & Rehabilitation Schedule
CapM, Inland Valley Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
CapM																
HMA	5	1,2		Year of Action	0	5		15	20							
				Activity Description	CapM (5 yr)	Rehab (10 yr)		CapM (5 yr)	Rehab (10 yr)							
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	5 / 1,096	10 / 2,675		5 / 1,096	10 / 2,675							
		3		Year of Action	0	5		15		20						
				Activity Description	CapM (5 yr)	CapM (5 yr)		CapM (5 yr)		CapM (5 yr)						
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	5 / 1,096	10 / 2,675		5 / 1,096		5 / 1,096						
	10	1,2		Year of Action	0		10			28			40			
				Activity Description	CapM (10 yr)		Rehab (20 yr)			CapM (10 yr)			Rehab (20 yr)			
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 2,675		18 / 1,392			12 / 2,312			18 / 1,252			
		3		Year of Action	0		10		20		30					
				Activity Description	CapM (10 yr)		CapM (10 yr)		CapM (10 yr)		CapM (10 yr)					
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 2,675		10 / 2,675		10 / 2,675		10 / 2,675					
HMA w/ OGFC	5	1,2		Year of Action	0		10			25						
				Activity Description	CapM w/ OGFC (5 yr)		Rehab w/ OGFC (10 yr)			CapM w/ OGFC (5 yr)						
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 3,464		15 / 2,247			10 / 3,464						
		3		Year of Action	0		10		10							
				Activity Description	CapM w/ OGFC (5 yr)		CapM w/ OGFC (5 yr)		CapM w/ OGFC (5 yr)							
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 3,464		10 / 3,464		10 / 3,464							
	10	1,2		Year of Action	0			15				35				
				Activity Description	CapM w/ OGFC (10 yr)			Rehab w/ OGFC (20 yr)				CapM w/ OGFC (10 yr)				
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	15 / 2,247			20 / 1,571				15 / 2,247				
		3		Year of Action	0			15								
				Activity Description	CapM w/ OGFC (10 yr)			CapM w/ OGFC (10 yr)								
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	15 / 2,247			15 / 2,247								

Table F2-1 (3)
Hot Mixed Asphalt Pavement Maintenance & Rehabilitation Schedule
Rehabilitation, Inland Valley Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
Rehabilitation																
HMA	10	1,2,3		Year of Action	0		9	15		25		35				
				Activity Description	Rehab (10 yr)		CapM (5 yr)	Rehab (10 yr)		CapM (5 yr)		Rehab (10 yr)				
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	9 / 2,940		6 / 895	10 / 2,675		10 / 2,675		10 / 2,675				
	20	1,2,3		Year of Action	0			18	23				41		51	
				Activity Description	Rehab (20 yr)			CapM (5 yr)	Rehab (20 yr)				CapM (5 yr)		Rehab (20 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	18 / 1,392			5 / 1,096	18 / 1,252				10 / 2,675		18 / 1,252	
HMA w/ OGFC	10	1,2,3		Year of Action	0			15		25			40			
				Activity Description	Rehab w/ OGFC (10 yr)			CapM w/ OGFC (5 yr)		Rehab w/ OGFC (10 yr)			CapM w/ OGFC (5 yr)			
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	15 / 2,247			10 / 3,464		15 / 2,247			10 / 3,464			
	20	1,2,3		Year of Action	0				20		30					
				Activity Description	Rehab w/ OGFC (20 yr)				CapM w/ OGFC (5 yr)		Rehab w/ OGFC (20 yr)					
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	20 / 1,571				10 / 3,464		24 / 2,726					
	40	1,2,3		Year of Action	0											
				Activity Description	Rehab w/ OGFC (40 yr)											
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life												

Table F2-2 (1)

Rubberized Asphalt Concrete Pavement Maintenance & Rehabilitation Schedule

New Construction/Reconstruction, Inland Valley Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
New Construction/Reconstruction																
RAC	20	1,2	1	Year of Action	0					26		36		46		
				Activity Description	New Const./ Reconst. (20 yr)					RAC Rehab (10 yr)		RAC CapM (5 yr)		RAC Rehab (10 yr)		
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	26 / 3,491					10 / 3,915		10 / 3915		10 / 3,915		
			2	Year of Action	0					26			42		52	
				Activity Description	New Const./ Reconst. (20 yr)					RAC Rehab (20 yr)			RAC CapM (5 yr)		RAC Rehab (20 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	26 / 3,491					16 / 2,153			10 / 3915		16 / 2,153	
		3		Year of Action	0					29		37	42	50	55	
				Activity Description	New Const./ Reconst. (20 yr)					RAC CapM (5 yr)		RAC CapM (5 yr)	RAC CapM (5 yr)	RAC CapM (5 yr)	Reconst. (20 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	26 / 3,491					8 / 0		5 / 0	8 / 0	5 / 0	16 / 2,153	
RAC w/ RAC-O	20	1,2	1													
			2													
		3														
	40	1,2														
		3														

Table F2-2 (2)
Rubberized Asphalt Concrete Pavement Maintenance & Rehabilitation Schedule
CapM, Inland Valley Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
CapM																
RAC	5	1,2		Year of Action	0	8		18		28						
				Activity Description	RAC CapM (5 yr)	RAC Rehab (10 yr)		RAC CapM (5 yr)		RAC Rehab (10 yr)						
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	8 / 0	10 / 3,915		10 / 3,915		10 / 3,915						
		3		Year of Action	0	8		18		25						
				Activity Description	RAC CapM (5 yr)	RAC CapM (5 yr)		RAC CapM (5 yr)		RAC CapM (5 yr)						
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	8 / 0	10 / 3,915		7 / 0		10 / 3,915						
	10	1,2		Year of Action	0		10					38				
				Activity Description	RAC CapM (10 yr)		RAC Rehab (20 yr)					RAC Rehab (20 yr)				
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 3,915		28 / 3,269					28 / 3,269				
		3		Year of Action	0		10		20		30					
				Activity Description	RAC CapM (10 yr)		RAC CapM (5 yr)		RAC CapM (10 yr)		RAC CapM (5 yr)					
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 3,915		10 / 3,915		10 / 3,915		10 / 3,915					
RAC w/ RAC-O	10	1,2														
		3														

Table F2-2 (3)
Rubberized Asphalt Concrete Pavement Maintenance & Rehabilitation Schedule
Rehabilitation, Inland Valley Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
Rehabilitation																
RAC	10	1,2,3		Year of Action	0		10	19		29						
				Activity Description	RAC Rehab (10 yr)		RAC CapM (5yr)	RAC Rehab (10yr)		CapM (5yr)						
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 3,915		9 / 4,270	10 / 3,915		9 / 4,270						
	20	1,2,3		Year of Action	0					25					50	
				Activity Description	RAC Rehab (20 yr)					RAC Rehab (20 yr)					RAC Rehab (20 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	25 / 3,572					16 / 2,153					16 / 2,153	
RAC w/ RAC-O	10	1,2,3														
	20	1,2,3														
	40	1,2,3														

Table F3-1 (1)
Hot Mixed Asphalt Pavement Maintenance & Rehabilitation Schedule
New Construction/Reconstruction, Desert Climate Region

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
New Construction/Reconstruction																
HMA	20	1,2	1	Year of Action	0			18	23		32	37		46	51	
				Activity Description	New Const./ Reconst. (20 yr)			CapM (5 yr)	Rehab (10 yr)		CapM (5 yr)	Rehab (10 yr)		CapM (5 yr)	Rehab (10 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	18 / 2,188			5 / 1,096	9 / 2,940		5 / 1,096	9 / 2,940		5 / 1,096	9 / 2,940	
			2	Year of Action	0			18	23				41		51	
				Activity Description	New Const./ Reconst. (20 yr)			CapM (5 yr)	Rehab (20 yr)				CapM (5 yr)		Rehab (20 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	18 / 2,188			5 / 1,096	18 / 2,188				10 / 5,459		18 / 2,188	
		3		Year of Action	0			18		28		38	43			
				Activity Description	New Const./ Reconst. (20 yr)			CapM (5 yr)		CapM (5 yr)		CapM (5 yr)	Reconstruct (20 yr)			
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	18 / 2,188			10 / 5,459		10 / 5,459		5 / 1,096	18 / 2,188			
HMA w/ OGFC	20	1,2	1	Year of Action	0				20	29			44		53	
				Activity Description	New Const./ Reconst. (20 yr)				CapM w/ OGFC (5 yr)	Rehab w/ OGFC (10 yr)			CapM w/ OGFC (5 yr)		Rehab w/ OGFC (10 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	20 / 3,235				9 / 3,779	15 / 2,247			9 / 3,779		15 / 2,247	
			2	Year of Action	0				20	29					53	
				Activity Description	New Const./ Reconst. (20 yr)				CapM w/ OGFC (5 yr)	Rehab w/ OGFC (20 yr)					CapM w/ OGFC (5 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	20 / 3,235				9 / 3,779	24 / 2,726					9 / 3,779	
		3		Year of Action	0				20	29		39		49		
				Activity Description	New Const./ Reconst. (20 yr)				CapM w/ OGFC (5 yr)	CapM w/ OGFC (5 yr)		CapM w/ OGFC (5 yr)		Reconstruct (20 yr)		
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	20 / 3,235				9 / 3,779	10 / 2,961		10 / 2,961		20 / 3,235		
	40	1,2		Year of Action	0								40		49	
				Activity Description	New Const./ Reconst. (40 yr)								CapM w/ OGFC (5 yr)		Rehab w/ OGFC (20 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	40 / 3,915								9 / 3,799		24 / 2726	
		3		Year of Action	0								40		49	
				Activity Description	New Const./ Reconst.								CapM w/ OGFC (5 yr)		CapM w/ OGFC (5 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	40 / 3,915								9 / 3,799		9 / 3,799	

Table F3-1 (2)
Hot Mixed Asphalt Pavement Maintenance & Rehabilitation Schedule
CapM, Desert Climate Region

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
CapM																
HMA	5	1,2		Year of Action	0	5	14	19								
				Activity Description	CapM (5 yr)	Rehab (10 yr)	CapM (5 yr)	Rehab (10 yr)								
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	5 / 1,096	9 / 2,940	5 / 1,096	9 / 2,940								
		3		Year of Action	0	5	10	15	20							
				Activity Description	CapM (5 yr)	CapM (5 yr)	CapM (5 yr)	CapM (5 yr)	CapM (5 yr)							
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	5 / 1,096	5 / 1,096	5 / 1,096	5 / 1,096	5 / 1,096							
	10	1,2		Year of Action	0		10			28		38				
				Activity Description	CapM (10 yr)		Rehab (20 yr)			CapM (10 yr)		Rehab (20 yr)				
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 2,675		18 / 1,406			10 / 2,675		18 / 1,406				
		3		Year of Action	0		10		20		30					
				Activity Description	CapM (10 yr)		CapM (10 yr)		CapM (10 yr)		CapM (10 yr)					
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 2,675		10 / 2,675		10 / 2,675		10 / 2,675					
HMA w/ OGFC	5	1,2		Year of Action	0		10		23							
				Activity Description	CapM w/ OGFC (5 yr)		Rehab w/ OGFC (10 yr)		Rehab w/ OGFC (10 yr)							
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 3,464		13 / 2,602		13 / 2,602							
		3		Year of Action	0		10		20							
				Activity Description	CapM w/ OGFC (5 yr)		CapM w/ OGFC (5 yr)		CapM w/ OGFC (5 yr)							
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 3,464		10 / 3,464		10 / 3,464							
	10	1,2		Year of Action	0		14					39				
				Activity Description	CapM w/ OGFC (10 yr)		Rehab w/ OGFC (20 yr)					CapM w/ OGFC (10 yr)				
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	14 / 2,459		25 / 2,767					14 / 2,459				
		3		Year of Action	0		14			28						
				Activity Description	CapM w/ OGFC (10 yr)		CapM w/ OGFC (10 yr)			CapM w/ OGFC (10 yr)						
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	14 / 2,459		14 / 2,459			14 / 2,459						

Table F3-1 (3)
Hot Mixed Asphalt Pavement Maintenance & Rehabilitation Schedule
Rehabilitation, Desert Climate Region

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
Rehabilitation																
HMA	10	1,2,3		Year of Action	0		10	15		25	30					
				Activity Description	Rehab (10 yr)		CapM (5 yr)	Rehab (10 yr)		CapM (5 yr)	Rehab (10 yr)					
				Activity Service Life (years)	10		5	10		5	10					
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	2,675		1,096	2,675		1,096	2,675					
	20	1,2,3		Year of Action	0			18	23				41		51	
				Activity Description	Rehab (20 yr)			CapM (5 yr)	Rehab (20 yr)				CapM (5 yr)		Rehab (20 yr)	
				Activity Service Life (years)	18			5	18				10		18	
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	2,188			1,096	2,188				2,675		2,188	
HMA w/ OGFC	10	1,2,3		Year of Action	0		13		22		32					
				Activity Description	Rehab w/ OGFC (10 yr)		CapM w/ OGFC (5 yr)		Rehab w/ OGFC (10 yr)		CapM w/ OGFC (5 yr)					
				Activity Service Life (years)	13		9		10		9					
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	2,602		3,779		3,464		3,779					
	20	1,2,3		Year of Action	0			18		27				45	54	
				Activity Description	Rehab w/ OGFC (20 yr)			CapM w/ OGFC (5 yr)		Rehab w/ OGFC (20 yr)				CapM w/ OGFC (5 yr)	Rehab w/ OGFC (20 yr)	
				Activity Service Life (years)	18			9		18				9	18	
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	2,052			3,779		$3,674				3,779	$3,674	
	40	1,2,3		Year of Action	0								40	49		
				Activity Description	Rehab w/ OGFC (40 yr)								CapM w/ OGFC (5 yr)	Rehab w/ OGFC (20 yr)		
				Activity Service Life (years)	40								9	18		
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	3,883								3,779	$3,674		

Table F3-2 (1)
Rubberized Asphalt Concrete Pavement Maintenance & Rehabilitation Schedule
New Construction/Reconstruction, Desert Climate Region

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
New Construction/Reconstruction																
RAC	20	1,2	1	Year of Action	0					26		36		46		
				Activity Description	New Const./ Reconst. (20 yr)					RAC Rehab (10 yr)		RAC CapM (5 yr)		RAC Rehab (10 yr)		
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	26 / 3,491					10 / 3,915		10 / 3,915		10 / 3,915		
			2	Year of Action	0					26			42		52	
				Activity Description	New Const./ Reconst. (20 yr)					RAC Rehab (20 yr)			RAC CapM (5 yr)		RAC Rehab (20 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	26 / 3,491					16 / 2,153			10 / 3,915		16 / 2,153	
		3		Year of Action	0					29		37	42	50	55	
				Activity Description	New Const./ Reconst. (20 yr)					RAC CapM (5 yr)		RAC CapM (5 yr)	RAC CapM (5 yr)	RAC CapM (5 yr)	New Const./ Reconst. (20	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	26 / 3,491					8 / 0		5 / 0	8 / 0	5 / 0	16 / 2,153	
RAC w/ RAC-O	20	1,2	1													
			2													
		3														
	40	1,2														
		3														

Table F3-2 (2)
Rubberized Asphalt Concrete Pavement Maintenance & Rehabilitation Schedule
CapM, Desert Climate Region

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
CapM																
RAC	5	1,2		Year of Action	0	8		18		26						
				Activity Description	RAC CapM (5 yr)	RAC Rehab (10 yr)		RAC CapM (5 yr)		RAC Rehab (10 yr)						
				Activity Service Life (years)	8	10		8		10						
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	0	3,915		5,101		3,915						
		3		Year of Action	0	8		18		25						
				Activity Description	RAC CapM (5 yr)	RAC CapM (5 yr)		RAC CapM (5 yr)		RAC CapM (5 yr)						
				Activity Service Life (years)	8	10		7		10						
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	5,101	3,915		0		3,915						
	10	1,2		Year of Action	0		10			26		38				
				Activity Description	RAC CapM (10 yr)		RAC Rehab (20 yr)			RAC CapM (5 yr)		RAC Rehab (20 yr)				
				Activity Service Life (years)	10		16			12		16				
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	3,915		2,153			$3,128		2,153				
		3		Year of Action	0		10		20		30					
				Activity Description	RAC CapM (10 yr)		RAC CapM (5 yr)		RAC CapM (10 yr)		RAC CapM (5 yr)					
				Activity Service Life (years)	10		10		10		10					
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	3,915		3,915		3,915		3,915					
RAC w/ RAC-O	10	1,2														
		3														

Table F3-2 (3)
Rubberized Asphalt Concrete Pavement Maintenance & Rehabilitation Schedule
Rehabilitation, Desert Climate Region

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
Rehabilitation																
RAC	10	1,2,3		Year of Action	0		10	18		28		36				
				Activity Description	RAC Rehab (10 yr)		RAC CapM (5 yr)	RAC Rehab (10 yr)		RAC CapM (5 yr)		RAC Rehab (10 yr)				
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 3,915		8 / 4,905	10 / 3,915		8 / 4,905		10 / 3,915				
	20	1,2,3		Year of Action	0				24					48		
				Activity Description	RAC Rehab (20 yr)				RAC Rehab (20 yr)					RAC Rehab (20 yr)		
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	24 / 3,704				24 / 3,704					16 / 2,153		
RAC w/ RAC-O	10	1,2,3														
	20	1,2,3														
	40	1,2,3														

Table F4-1 (1)
Hot Mixed Asphalt Pavement Maintenance & Rehabilitation Schedule
New Construction/Reconstruction, Low Mountain and South Mountain Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
New Construction/Reconstruction																
HMA	20	1,2	1	Year of Action	0			19	24		34	39		49	54	
				Activity Description	New Const./ Reconst. (20 yr)			CapM (5 yr)	Rehab (10 yr)		CapM (5 yr)	Rehab (10 yr)		CapM (5 yr)	Rehab (10 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	19 / 1,552			5 / 3,112	10 / 1,579		5 / 3,112	10 / 1,579		5 / 3,112	10 / 1,579	
			2	Year of Action	0			19	24				43	48		
				Activity Description	New Const./ Reconst. (20 yr)			CapM (5 yr)	Rehab (20 yr)				CapM (5 yr)	Rehab (20 yr)		
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	19 / 1,552			5 / 3,112	19 / 1,552				5 / 3,112	19 / 1,552		
		3		Year of Action	0			19			31		43			55
				Activity Description	New Const./ Reconst. (20 yr)			CapM (5 yr)			CapM (5 yr)		CapM (5 yr)			CapM (5 yr)
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	19 / 1,552			12 / 6,146			12 / 6,146		12 / 6,146			12 / 6,146
HMA w/ OGFC	20	1,2	1	Year of Action	0				23	29		39	44		54	
				Activity Description	New Const./ Reconst. (20 yr)				CapM w/ OGFC (5 yr)	Rehab w/ OGFC (10 yr)		CapM w/ OGFC (5 yr)	Rehab (10 yr)		Rehab w/ OGAC (20 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	23 / 4,141				6 / 0	10 / 3,464		5 / 0	10 / 3,464		23 / $4,141	
			2	Year of Action	0				23	29					52	
				Activity Description	New Const./ Reconst. (20 yr)				CapM w/ OGFC (5 yr)	Rehab w/ OGFC (20 yr)					CapM w/ OGFC (5 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	23 / 4,141				6 / 0	23 / 4,141					6 / 0	
		3		Year of Action	0				20	29		38		47		
				Activity Description	New Const./ Reconst. (20 yr)				CapM w/ OGFC (5 yr)	CapM w/ OGFC (5 yr)		CapM w/ OGFC (5 yr)		Reconstruct (20 yr)		
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	20 / 3,235				9 / 3,779	9 / 3,779		9 / 3,779		20 / 3,235		
	40	1,2		Year of Action	0								40	46		
				Activity Description	New Const./ Reconst. (40 yr)								CapM w/ OGFC (5 yr)	Rehab w/ OGFC (20 yr)		
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	40 / 4,117								6 / 0	23 / 4,141		
		3		Year of Action	0								40	49		
				Activity Description	New Const./ Reconst.								CapM w/ OGFC (5 yr)	CapM w/ OGFC (5 yr)		
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	40 / 4,117								9 / 3,779	9 / 3,779		

Table F4-1 (2)
Hot Mixed Asphalt Pavement Maintenance & Rehabilitation Schedule
CapM, Low Mountain and South Mountain Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
CapM																
HMA	5	1,2		Year of Action	0	5		15	20							
				Activity Description	CapM (5 yr)	Rehab (10 yr)		CapM (5 yr)	Rehab (10 yr)							
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	5 / 3,112	10 / 7,187		5 / 3,112	10 / 7,187							
		3		Year of Action	0		12		24							
				Activity Description	CapM (5 yr)		CapM (5 yr)		CapM (5 yr)							
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	12 / 6,122		12 / 6,122		12 / 6,122							
	10	1,2		Year of Action	0		10				30					
				Activity Description	CapM (10 yr)		Rehab (20 yr)				CapM (10 yr)					
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 1,579		20 / 1,412				10 / 1,579					
		3		Year of Action	0			15			30					
				Activity Description	CapM (10 yr)			CapM (10 yr)			CapM (10 yr)					
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	15 / 2,099			15 / 2,099			15 / 2,099					
HMA w/ OGFC	5	1,2		Year of Action	0		10		23							
				Activity Description	CapM w/ OGFC (5 yr)		Rehab w/ OGFC (10 yr)		CapM w/ OGFC (5 yr)							
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 3,464		13 / 2,602		10 / 3,464							
		3		Year of Action	0		11		22							
				Activity Description	CapM w/ OGFC (5 yr)		CapM w/ OGFC (5 yr)		CapM w/ OGFC (5 yr)							
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	11 / 6,329		11 / 6,329		11 / 6,329							
	10	1,2		Year of Action	0		13					36				
				Activity Description	CapM w/ OGFC (10 yr)		Rehab w/ OGFC (20 yr)					CapM w/ OGFC (10 yr)				
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	13 / 2,623		23 / 4,480					13 / 2,623				
		3		Year of Action	0			15			30					
				Activity Description	CapM w/ OGFC (10 yr)			CapM w/ OGFC (10 yr)			CapM w/ OGFC (10 yr)					
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	15 / 6,882			15 / 6,882			15 / 6,882					

Table F4-1 (3)
Hot Mixed Asphalt Pavement Maintenance & Rehabilitation Schedule
Rehabilitation, Low Mountain and South Mountain Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
Rehabilitation																
HMA	10	1,2,3		Year of Action	0		10	15		25	30					
				Activity Description	Rehab (10 yr)		CapM (5 yr)	Rehab (10 yr)		CapM (5 yr)	Rehab (10 yr)					
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 1,579		5 / 3,112	10 / 1,579		5 / 3,112	10 / 1,579					
	20	1,2,3		Year of Action	0			19	24				43	48		
				Activity Description	Rehab (20 yr)			CapM (5 yr)	Rehab (20 yr)				CapM (5 yr)	Rehab (20 yr)		
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	19 / 1,552			5 / 3,112	19 / 1,552				5 / 3,112	19 / 1,552		
HMA w/ OGFC	10	1,2,3		Year of Action	0		12	18			30	36				
				Activity Description	Rehab w/ OGFC (10 yr)		CapM w/ OGFC (5 yr)	Rehab w/ OGFC (10 yr)			CapM w/ OGFC (5 yr)	Rehab w/ OGFC (10 yr)				
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	12 / 5,787		6 / 0	12 / 5,787			6 / 0	12 / 5,787				
	20	1,2,3		Year of Action	0				23	29					52	
				Activity Description	Rehab w/ OGFC (20 yr)				CapM w/ OGFC (5 yr)	Rehab w/ OGFC (20 yr)					CapM w/ OGFC (5 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	23 / 4,141				6 / 0	23 / 4,141					6 / 0	
	40	1,2,3		Year of Action	0								40	46		
				Activity Description	Rehab w/ OGFC (40 yr)								CapM w/ OGFC (5 yr)	Rehab w/ OGFC (20 yr)		
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	40 / 4,117								6 / 0	23 / 4,141		

Table F4-2 (1)
Rubberized Asphalt Concrete Pavement Maintenance & Rehabilitation Schedule
New Construction/Reconstruction, Low Mountain and South Mountain Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
New Construction/Reconstruction																
RAC	20	1,2	1	Year of Action	0					26		36		46		
				Activity Description	New Const./ Reconst. (20 yr)					RAC Rehab (10y)		RAC CapM (5 yr)		RAC Rehab (10y)		
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	26 / 3,491					10 / 3,915		10 / 3,915		10 / 3,915		
			2	Year of Action	0					26			42		52	
				Activity Description	New Const./ Reconst. (20 yr)					RAC Rehab (20 yr)			RAC CapM (5 yr)		RAC Rehab (20 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	26 / 3,491					16 / 2,153			10 / 3,915		16 / 2,153	
		3		Year of Action	0					29		37	42	50	55	
				Activity Description	New Const./ Reconst. (20 yr)					RAC CapM (5 yr)		RAC CapM (5 yr)	RAC CapM (5 yr)	RAC CapM (5 yr)	Reconst. (20 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	26 / 3,491					8 / 0		5 / 0	8 / 0	5 / 0	16 / 2,153	
RAC w/ RAC-O	20	1,2	1													
			2													
		3														
	40	1,2														
		3														

Table F4-2 (2)
Rubberized Asphalt Concrete Pavement Maintenance & Rehabilitation Schedule
CapM, Low Mountain and South Mountain Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
CapM																
RAC	5	1,2		Year of Action	0	8		18		26						
				Activity Description	RAC CapM (5 yr)	RAC Rehab (10 yr)		RAC CapM (5 yr)		RAC Rehab (10 yr)						
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	8 / 0	10 / 3,915		8 / 5,101		10 / 3,915						
		3		Year of Action	0	8		18		25						
				Activity Description	RAC CapM (5 yr)	RAC CapM (5 yr)		RAC CapM (5 yr)		RAC CapM (5 yr)						
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	8 / 5,101	10 / 3,915		7 / 0		10 / 3,915						
	10	1,2		Year of Action	0		10			26		38				
				Activity Description	RAC CapM (10 yr)		RAC Rehab (20 yr)			RAC CapM (5 yr)		RAC Rehab (20 yr)				
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 3,915		16 / 2,153			12 / 3,128		16 / 2,153				
		3		Year of Action	0		10		20		30					
				Activity Description	RAC CapM (10 yr)		RAC CapM (5 yr)		RAC CapM (10 yr)		RAC CapM (5 yr)					
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 3,915		10 / 3,915		10 / 3,915		10 / 3,915					
RAC w/ RAC-O	10	1,2														
		3														

Table F4-2 (3)
Rubberized Asphalt Concrete Pavement Maintenance & Rehabilitation Schedule
Rehabilitation, Low Mountain and South Mountain Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
Rehabilitation																
RAC	10	1,2,3		Year of Action	0		10	18		28		36				
				Activity Description	RAC Rehab (10 yr)		RAC CapM (5 yr)	RAC Rehab (10 yr)		RAC CapM (5 yr)		RAC Rehab (10 yr)				
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 3,915		8 / 4,905	10 / 3,915		8 / 4,905		10 / 3,915				
	20	1,2,3		Year of Action	0				24					48		
				Activity Description	RAC Rehab (20 yr)				RAC Rehab (20 yr)					RAC Rehab (20 yr)		
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	24 / 3,704				24 / 3,704					16 / 2,153		
RAC w/ RAC-O	10	1,2,3														
	20	1,2,3														
	40	1,2,3														

Table F5-1 (1)
Hot Mixed Asphalt Pavement Maintenance & Rehabilitation Schedule
New Construction/Reconstruction, High Mountain and High Desert Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0		5	10	15		20		25	30		35		40		45		50		55	
New Construction/Reconstruction																										
HMA	20	1,2	1	Year of Action	0				19		24			34		39				49		54				
				Activity Description	New Const./ Reconst. (20 yr)				CapM (5 yr)		Rehab (10 yr)			CapM (5 yr)		Rehab (10 yr)				CapM (5 yr)		Rehab (10 yr)				
				Activity Service Life (years)	Annual Maint. Cost ($/lane-mile) over Activity Service Life				5	3,112	10	1,579		5	3,112	10	1,579			5	3,112	10	1,579				
			2	Year of Action	0				19		24							43		48						
				Activity Description	New Const./ Reconst. (20 yr)				CapM (5 yr)		Rehab (20 yr)							CapM (5 yr)		Rehab (20 yr)						
				Activity Service Life (years)	Annual Maint. Cost ($/lane-mile) over Activity Service Life				5	3,112	19	1,552						5	3,112	19	1,552					
		3		Year of Action	0				19					31				43							55	
				Activity Description	New Const./ Reconst. (20 yr)				CapM (5 yr)					CapM (5 yr)				CapM (5 yr)							CapM (5 yr)	
				Activity Service Life (years)	Annual Maint. Cost ($/lane-mile) over Activity Service Life				12	6,146				12	6,146			12	6,146						12	6,146

Table F5-1 (2)
Hot Mixed Asphalt Pavement Maintenance & Rehabilitation Schedule
CapM, High Mountain and High Desert Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
CapM																
HMA	5	1,2		Year of Action	0	5		15	20							
				Activity Description	CapM (5 yr)	Rehab (10 yr)		CapM (5 yr)	Rehab (10 yr)							
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	5 / 3,112	10 / 7,187		5 / 3,112	10 / 7,187							
		3		Year of Action	0		12		24							
				Activity Description	CapM (5 yr)		CapM(5 yr)		CapM(5 yr)							
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	12 / 6,122		12 / 6,122		12 / 6,122							
	10	1,2		Year of Action	0		10				30					
				Activity Description	CapM (10 yr)		Rehab (20 yr)				CapM (10 yr)					
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 1,579		20 / 1,412				10 / 1,579					
		3		Year of Action	0			15			30					
				Activity Description	CapM (10 yr)			CapM (10 yr)			CapM (10 yr)					
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	15 / 2,099			15 / 2,099			15 / 2,099					

Table F5-1 (3)
Hot Mixed Asphalt Pavement Maintenance & Rehabilitation Schedule
Rehabilitation, High Mountain and High Desert Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
Rehabilitation																
HMA	10	1,2,3		Year of Action	0		10	15		25	30					
				Activity Description	Rehab (10 yr)		CapM (5 yr)	Rehab (10 yr)		CapM (5 yr)	Rehab (10 yr)					
				Activity Service Life (years)	10		5	10		5	10					
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	1,579		3,112	1,579		3,112	1,579					
	20	1,2,3		Year of Action	0			19	24				43	48		
				Activity Description	Rehab (20 yr)			CapM (5 yr)	Rehab (20 yr)				CapM (5 yr)	Rehab (20 yr)		
				Activity Service Life (years)	19			5	19				5	19		
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	1,552			3,112	1,552				3,112	1,552		

Table F5-2 (1)
Rubberized Asphalt Concrete Pavement Maintenance & Rehabilitation Schedule
New Construction/Reconstruction, High Mountain and High Desert Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
New Construction/Reconstruction																
RAC	20	1,2	1	Year of Action	0					26		36		46		
				Activity Description	New Const./ Reconst. (20 yr)					RAC Rehab (10 yr)		RAC CapM (5 yr)		RAC Rehab (10 yr)		
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	26 / 3,491					10 / 3,915		10 / 3,915		10 / 3,915		
		1,2	2	Year of Action	0					26			42		52	
				Activity Description	New Const./ Reconst. (20 yr)					RAC Rehab (20 yr)			RAC CapM (5 yr)		RAC Rehab (20 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	26 / 3,491					16 / 2,153			10 / 3,915		16 / 2,153	
		3		Year of Action	0					29		37	42	50	55	
				Activity Description	New Const./ Reconst. (20 yr)					RAC CapM (5 yr)		RAC CapM (5 yr)	RAC CapM (5 yr)	RAC CapM (5 yr)	Reconst. (20 yr)	
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	26 / 3,491					8 / 0		5 / 0	8 / 0	5 / 0	16 / 2,153	
RAC w/ RAC-O	20	1,2	1													
			2													
		3														
	40	1,2														
		3														

Table F5-2 (2)
Rubberized Asphalt Concrete Pavement Maintenance & Rehabilitation Schedule
CapM, High Mountain and High Desert Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
CapM																
RAC	5	1,2		Year of Action	0	8		18		26						
				Activity Description	RAC CapM (5 yr)	RAC Rehab (10 yr)		RAC CapM (5 yr)		RAC Rehab (10 yr)						
				Activity Service Life (years)	8	10		8		10						
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	0	3,915		5,101		3,915						
		3		Year of Action	0	8		18		25						
				Activity Description	RAC CapM (5 yr)	RAC CapM (5 yr)		RAC CapM (5 yr)		RAC CapM (5 yr)						
				Activity Service Life (years)	8	10		7		10						
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	5,101	3,915		0		3,915						
	10	1,2		Year of Action	0		10			26		38				
				Activity Description	RAC CapM (10 yr)		RAC Rehab (20 yr)			RAC CapM (5 yr)		RAC Rehab (20 yr)				
				Activity Service Life (years)	10		16			12		16				
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	3,915		2,153			3,128		2,153				
		3		Year of Action	0		10		20		30					
				Activity Description	RAC CapM (10 yr)		RAC CapM (5 yr)		RAC CapM (10 yr)		RAC CapM (5 yr)					
				Activity Service Life (years)	10		10		10		10					
				Annual Maint. Cost ($/lane-mile) over Activity Service Life	3,915		3,915		3,915		3,915					
RAC w/ RAC-O	10	1,2														
		3														

Table F5-2 (3)
Rubberized Asphalt Concrete Pavement Maintenance & Rehabilitation Schedule
Rehabilitation, High Mountain and High Desert Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
Rehabilitation																
RAC	10	1,2,3		Year of Action	0		10	18		28		36				
				Activity Description	RAC Rehab (10 yr)		RAC CapM (5 yr)	RAC Rehab (10 yr)		RAC CapM (5 yr)		RAC Rehab (10 yr)				
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 3,915		8 / 4,905	10 / 3,915		8 / 4,905		10 / 3,915				
	20	1,2,3		Year of Action	0				24					48		
				Activity Description	RAC Rehab (20 yr)				RAC Rehab (20 yr)					RAC Rehab (20 yr)		
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	24 / 3,704				24 / 3,704					16 / 2,153		
RAC w/ RAC-O	10	1,2,3														
	20	1,2,3														
	40	1,2,3														

Table R1 (1)

Rigid Pavement Maintenance & Rehabilitation Schedule

New Construction/Reconstruction, Inland Valley, Dessert, Low Mountain, South Mountain, and All Coastal Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
New Construction/Reconstruction																
New Lane	20	1,2,3		Year of Action	0				20		30	35	40	*Follow the strategy listed in this table for the Roadway Rehabilitation Option selected.*		
				Activity Description	New Const./ Reconst. (20 yr)				10-yr CapM (Conc Pvmt Rehab #3*)		5-yr CapM (Conc Pvmt Rehab #2*)	5-yr CapM (Conc Pvmt Rehab #1*)	Roadway Rehab*			
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	20 / 952				10 / 2,098		5 / 4,135	5 / 4,135				
	40	1,2,3		Year of Action	0								40		50	55
				Activity Description	New Const./ Reconst.								10-yr CapM (Conc Pvmt Rehab #3*)		5-yr CapM (Conc Pvmt Rehab #2*)	5-yr CapM (Conc Pvmt Rehab #1*)
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	40 / 366								10 / 2,098		5 / 4,135	5 / 4,135

Notes:

1. Concrete Pavement Rehabilitation #1 involves pavement grinding, significant slab replacement, spall repair, & joint seal repair. It is for projects with a total number of slabs in the lane that exhibit third stat were previously replaced is greater than or equal to 5% and less than or equal to 7%. For greater than 7%, the project should be scoped and analyzed as a roadway rehabilitation project.
2. Concrete Pavement Rehabilitation #2 involves pavement grinding, moderate slab replacement, spall repair, & joint seal repair. It is for projects with a total number of slabs in the lane that exhibit third state were previously replaced is between 2 and 5%.
3. Concrete Pavement Rehabilitation #3 involves pavement grinding, minor slab replacement, spall repair, & joint seal repair. It is for projects with a total number of slabs in the lane that exhibit third state Rig were previously replaced is 2% or less.
4. Select the roadway rehabilitation option found in this table that would best represent how the project will be rehabilitated in the future.

Table R1 (2)

Rigid Pavement Maintenance & Rehabilitation Schedule

CapM, Inland Valley, Dessert, Low Mountain, South Mountain, and All Coastal Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
CapM																
Conc Pvmt Rehab #1*	5	1,2,3		Year of Action	0	5	Follow the strategy listed in this table for the Roadway Rehabilitation Option selected.									
				Activity Description	5-yr CapM (Conc Pvmt Rehab #1*)	Roadway Rehab*										
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	5 / 4,135											
Conc Pvmt Rehab #2*	5	1,2,3		Year of Action	0	5	10	Follow the strategy listed in this table for the Roadway Rehabilitation Option selected.								
				Activity Description	5-yr CapM (Conc Pvmt Rehab #2*)	5-yr CapM (Conc Pvmt Rehab #1*)	Roadway Rehab*									
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	5 / 4,135	5 / 4,135										
Conc Pvmt Rehab #3*	10	1,2,3		Year of Action	0		10	15	20	Follow the strategy listed in this table for the Roadway Rehabilitation Option selected.						
				Activity Description	10-yr CapM (Conc Pvmt Rehab #3*)		5-yr CapM (Conc Pvmt Rehab #2*)	5-yr CapM (Conc Pvmt Rehab #1*)	Roadway Rehab*							
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 2,098		5 / 4,135	5 / 4,135								

Notes:

1. Concrete Pavement Rehabilitation #1 involves pavement grinding, significant slab replacement, spall repair, & joint seal repair. It is for projects with a total number of slabs in the lane that exhibit third stat were previously replaced is greater than or equal to 5% and less than or equal to 7%. For greater than 7%, the project should be scoped and analyzed as a roadway rehabilitation project.
2. Concrete Pavement Rehabilitation #2 involves pavement grinding, moderate slab replacement, spall repair, & joint seal repair. It is for projects with a total number of slabs in the lane that exhibit third state were previously replaced is between 2 and 5%.
3. Concrete Pavement Rehabilitation #3 involves pavement grinding, minor slab replacement, spall repair, & joint seal repair. It is for projects with a total number of slabs in the lane that exhibit third state Rig were previously replaced is 2% or less.
4. Select the roadway rehabilitation option found in this table that would best represent how the project will be rehabilitated in the future.

Table R1 (3)

Rigid Pavement Maintenance & Rehabilitation Schedule

Rehabilitation, Inland Valley, Dessert, Low Mountain, South Mountain, and All Coastal Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
Rehabilitation																
Lane Replacement	20	1,2,3		Year of Action	0				20		30	35	40			
				Activity Description	20-yr Rehab (Lane Replacement)				10-yr CapM (Conc Pvmt Rehab #3*)		5-yr CapM (Conc Pvmt Rehab #2*)	5-yr CapM (Conc Pvmt Rehab #1*)	Roadway Rehab*	Follow the strategy listed in this table for the Roadway Rehabilitation Option selected.		
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	20 / 952				10 / 2,098		5 / 4,135	5 / 4,135				
Lane Replacement	40	1,2,3		Year of Action	0								40		50	55
				Activity Description	40-yr Rehab (Lane Replacement)								10-yr CapM (Conc Pvmt Rehab #3*)		5-yr CapM (Conc Pvmt Rehab #2*)	5-yr CapM (Conc Pvmt Rehab #1*)
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	40 / 366								10 / 2,098		5 / 4,135	5 / 4,135
Rigid Crack, Seat, w/ 0.45' AC Overlay	20	1,2,3		Year of Action	0			18	23	28	33		42	49		
				Activity Description	20-yr Rehab (CSOL)			5-yr CapM (0.10' HMA Overlay)	5-yr CapM (0.15' HMA Overlay +2% Digout)	5-yr CapM (0.10' HMA Overlay)	10-yr Rehab (0.25' HMA Overlay +5% Digout)		5-yr CapM (0.15' HMA Overlay +2% Digout)	Reconst		
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	18 / 1,321			5 / 0	5 / 0	5 / 0	9 / 631		7 / 813			
Rigid Crack, Seat, w/ 0.35' AC Overlay	10	1,2,3		Year of Action	0	9	14	19	24		33		40			
				Activity Description	10-yr Rehab (CSOL)	5-yr CapM (0.10' HMA Overlay)	5-yr CapM (0.15' HMA Overlay +2% Digout)	5-yr CapM (0.10' HMA Overlay)	10-yr Rehab (0.25' HMA Overlay +5% Digout)		5-yr CapM (0.15' HMA Overlay +2% Digout)		Reconst			
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	9 / 0	5 / 0	5 / 0	5 / 0	9 / 631		7 / 813					

Notes:

1. Concrete Pavement Rehabilitation #1 involves pavement grinding, significant slab replacement, spall repair, & joint seal repair. It is for projects with a total number of slabs in the lane that exhibit third stat were previously replaced is greater than or equal to 5% and less than or equal to 7%. For greater than 7%, the project should be scoped and analyzed as a roadway rehabilitation project.
2. Concrete Pavement Rehabilitation #2 involves pavement grinding, moderate slab replacement, spall repair, & joint seal repair. It is for projects with a total number of slabs in the lane that exhibit third state were previously replaced is between 2 and 5%.
3. Concrete Pavement Rehabilitation #3 involves pavement grinding, minor slab replacement, spall repair, & joint seal repair. It is for projects with a total number of slabs in the lane that exhibit third state Rig were previously replaced is 2% or less.
4. Select the roadway rehabilitation option found in this table that would best represent how the project will be rehabilitated in the future.

Table R2 (1)

Rigid Pavement Maintenance & Rehabilitation Schedule

New Construction/Reconstruction, High Mountain and High Desert Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
New Construction/Reconstruction																
New Lane	20	1,2,3		Year of Action	0				20		30	35	40	*Follow the strategy listed in this table for the Roadway Rehabilitation Option selected.*		
				Activity Description	New Const./ Reconst. (20 yr)				10-yr CapM (Conc Pvmt Rehab #3*)		5-yr CapM (Conc Pvmt Rehab #2*)	5-yr CapM (Conc Pvmt Rehab #1*)	Roadway Rehab*			
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	20 / 2,156				10 / 2,098		5 / 4,135	5 / 4,135				
	40	1,2,3		Year of Action	0								40		50	55
				Activity Description	New Const./ Reconst.								10-yr CapM (Conc Pvmt Rehab #3*)		5-yr CapM (Conc Pvmt Rehab #2*)	5-yr CapM (Conc Pvmt Rehab #1*)
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	40 / 3,710								10 / 2,098		5 / 4,135	5 / 4,135

Notes:

1. Concrete Pavement Rehabilitation #1 involves pavement grinding, significant slab replacement, spall repair, & joint seal repair. It is for projects with a total number of slabs in the lane that exhibit third stat were previously replaced is greater than or equal to 5% and less than or equal to 7%. For greater than 7%, the project should be scoped and analyzed as a roadway rehabilitation project.
2. Concrete Pavement Rehabilitation #2 involves pavement grinding, moderate slab replacement, spall repair, & joint seal repair. It is for projects with a total number of slabs in the lane that exhibit third state were previously replaced is between 2 and 5%.
3. Concrete Pavement Rehabilitation #3 involves pavement grinding, minor slab replacement, spall repair, & joint seal repair. It is for projects with a total number of slabs in the lane that exhibit third state Rig were previously replaced is 2% or less.
4. Select the roadway rehabilitation option found in this table that would best represent how the project will be rehabilitated in the future.

Table R1 (2)
Rigid Pavement Maintenance & Rehabilitation Schedule
CapM, High Mountain and High Desert Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
CapM																
Conc Pvmt Rehab #1*	5	1,2,3		Year of Action	0	5	Follow the strategy listed in this table for the Roadway Rehabilitation Option selected.									
				Activity Description	5-yr CapM (Conc Pvmt Rehab #1*)	Roadway Rehab*										
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	5 / 4,135											
Conc Pvmt Rehab #2*	5	1,2,3		Year of Action	0	5	10	Follow the strategy listed in this table for the Roadway Rehabilitation Option selected.								
				Activity Description	5-yr CapM (Conc Pvmt Rehab #2*)	5-yr CapM (Conc Pvmt Rehab #1*)	Roadway Rehab*									
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	5 / 4,135	5 / 4135										
Conc Pvmt Rehab #3*	10	1,2,3		Year of Action	0		10	15	20	Follow the strategy listed in this table for the Roadway Rehabilitation Option selected.						
				Activity Description	10-yr CapM (Conc Pvmt Rehab #3*)		5-yr CapM (Conc Pvmt Rehab #2*)	5-yr CapM (Conc Pvmt Rehab #1*)	Roadway Rehab*							
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	10 / 2,098		5 / 4135	5 / 4,135								

Notes:

1. Concrete Pavement Rehabilitation #1 involves pavement grinding, significant slab replacement, spall repair, & joint seal repair. It is for projects with a total number of slabs in the lane that exhibit third stat were previously replaced is greater than or equal to 5% and less than or equal to 7%. For greater than 7%, the project should be scoped and analyzed as a roadway rehabilitation project.
2. Concrete Pavement Rehabilitation #2 involves pavement grinding, moderate slab replacement, spall repair, & joint seal repair. It is for projects with a total number of slabs in the lane that exhibit third state were previously replaced is between 2 and 5%.
3. Concrete Pavement Rehabilitation #3 involves pavement grinding, minor slab replacement, spall repair, & joint seal repair. It is for projects with a total number of slabs in the lane that exhibit third state Rig were previously replaced is 2% or less.
4. Select the roadway rehabilitation option found in this table that would best represent how the project will be rehabilitated in the future.

Table R1 (3)

Rigid Pavement Maintenance & Rehabilitation Schedule

Rehabilitation, High Mountain and High Desert Climate Regions

Final Surface Type	Pvmt Design Life	Maint. Service Level	Option	Year	0	5	10	15	20	25	30	35	40	45	50	55
Rehabilitation																
Lane Replacement	20	1,2,3		Year of Action	0				20		30	35	40	Follow the strategy listed in this table for the Roadway Rehabilitation Option selected.		
				Activity Description	20-yr Rehab (Lane Replacement)				10-yr CapM (Conc Pvmt Rehab #3*)		5-yr CapM (Conc Pvmt Rehab #2*)	5-yr CapM (Conc Pvmt Rehab #1*)	Roadway Rehab*			
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	20 / 952				10 / 2,098		5 / 4,135	5 / 4,135				
Lane Replacement	40	1,2,3		Year of Action	0								40		50	55
				Activity Description	40-yr Rehab (Lane Replacement)								10-yr CapM (Conc Pvmt Rehab #3*)		5-yr CapM (Conc Pvmt Rehab #2*)	5-yr CapM (Conc Pvmt Rehab #1*)
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	40 / 366								10 / 2,098		5 / $4,135	5 / 4,135
Rigid Crack, Seat, w/ 0.45' HMA Overlay	20	1,2,3		Year of Action	0			18	23	28	33		42	49		
				Activity Description	20-yr Rehab (CSOL)			5-yr CapM (0.10' HMA Overlay)	5-yr CapM (0.15' HMA Overlay +2% Digout)	5-yr CapM (0.10' HMA Overlay)	10-yr Rehab (0.40' HMA Overlay +5% Digout)		5-yr CapM (0.15' HMA Overlay +2% Digout)	Reconst		
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	18 / 1,321			5 / 0	5 / 0	5 / 0	9 / 631		7 / 813			
Rigid Crack, Seat, w/ 0.35' HMA Overlay	10	1,2,3		Year of Action	0	9	14	19	24		33		40			
				Activity Description	10-yr Rehab (CSOL)	5-yr CapM (0.10' HMA Overlay)	5-yr CapM (0.15' HMA Overlay +2% Digout)	5-yr CapM (0.10' HMA Overlay)	10-yr Rehab (0.35' HMA Overlay +5% Digout)		5-yr CapM (0.15' HMA Overlay +2% Digout)		Reconst			
				Activity Service Life (years) / Annual Maint. Cost ($/lane-mile) over Activity Service Life	9 / 0	5 / 0	5 / 0	5 / 0	9 / 631		7 / 813					

Notes:

1. Concrete Pavement Rehabilitation #1 involves pavement grinding, significant slab replacement, spall repair, & joint seal repair. It is for projects with a total number of slabs in the lane that exhibit third stat were previously replaced is greater than or equal to 5% and less than or equal to 7%. For greater than 7%, the project should be scoped and analyzed as a roadway rehabilitation project.
2. Concrete Pavement Rehabilitation #2 involves pavement grinding, moderate slab replacement, spall repair, & joint seal repair. It is for projects with a total number of slabs in the lane that exhibit third state were previously replaced is between 2 and 5%.
3. Concrete Pavement Rehabilitation #3 involves pavement grinding, minor slab replacement, spall repair, & joint seal repair. It is for projects with a total number of slabs in the lane that exhibit third state Rig were previously replaced is 2% or less.
4. Select the roadway rehabilitation option found in this table that would best represent how the project will be rehabilitated in the future.

APPENDIX 3: MAXIMUM QUEUE LENGTH ESTIMATION

The maximum number of queued vehicles during which the work zone is in effect is estimated by the traffic demand-capacity model, as shown in Figure 24. When demand exceeds capacity, the queue starts to build up. The maximum number of queued vehicles is measured where the difference between the demand curve and the capacity curve is the greatest. Then the maximum queue length can be obtained by multiplying the maximum number of queued vehicles by the average vehicle length (i.e., 40 feet).

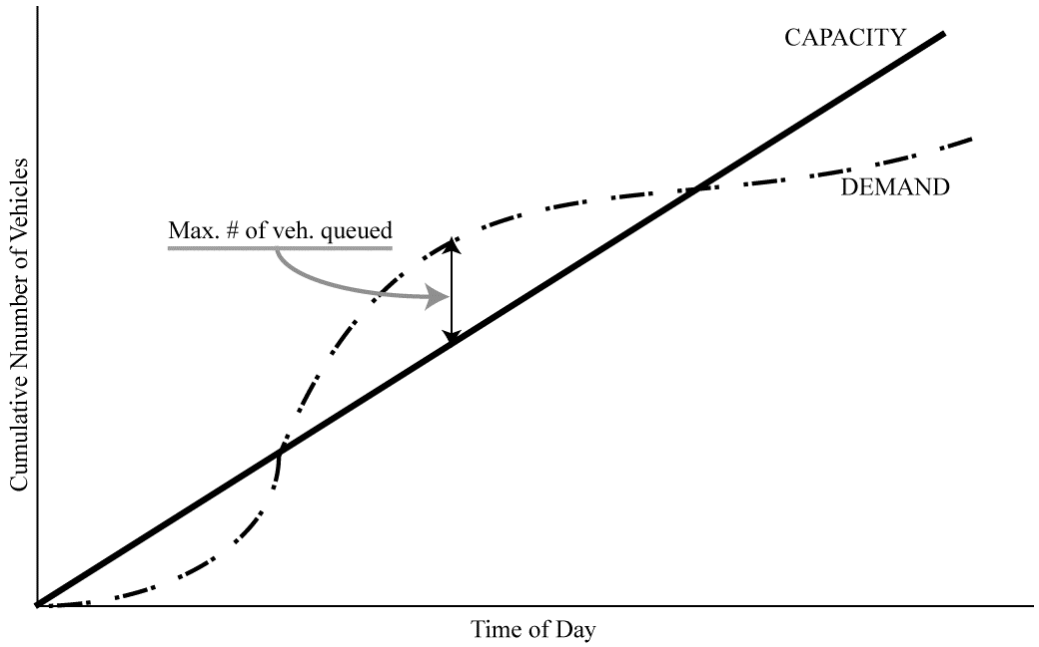


Figure 24. Traffic Demand-Capacity Model

Sample Maximum Queue Length Estimation

During construction on a three-lane urban freeway section, one lane will be closed and two lanes will be open. The work zone capacity is assumed as 1,600 pcphpl (passenger cars per hour per lane). The hourly traffic demands, expressed in vehicle per hour (vph), are assumed to be those shown in the second column in Table 14. Ten percent of the traffic volume is assumed to be

occupied by single-unit and combination trucks. The procedure for estimating the maximum queue length are:

- The hourly passenger car capacity of one lane (1,600 pcphpl) of the work zone is converted to the hourly vehicular capacity of one lane [1,524 vphpl (vehicles per hour per lane)] of the work zone using the following equation:

  $$vphpl = pcphpl \times f_{HV}$$

  where *vphpl* = vehicle per hour per lane
  pcphpl = passenger car per hour per lane.

  $$f_{HV} = \frac{100}{[100 + P \times (E - 1)]}$$

  where
  f_{HV} = heavy vehicle adjustment factor (vehicle/passenger car),
  P = percentage of heavy vehicles, and
  E = passenger car equivalent (passenger cars/heavy vehicle).
  Refer to the table below for an E value corresponding to a type of terrain at the project site)

	Type of Terrain		
	Level	**Rolling**	**Mountainous**
E	1.5	2.5	4.5

Table 14. Maximum Queue Length Estimation

Hour	Volume (vph)	Capacity (pcphpl)	Capacity (vphpl)	No. of lanes open	Capacity (vph)	Queued veh	
1	340	1,600	1,524	2	3,048	0	
2	350	1,600	1,524	2	3,048	0	
3	350	1,600	1,524	2	3,048	0	
4	400	1,600	1,524	2	3,048	0	
5	800	1,600	1,524	2	3,048	0	
6	1,200	1,600	1,524	2	3,048	0	
7	3,000	1,600	1,524	2	3,048	0	
8	3,400	1,600	1,524	2	3,048	352	
9	3,600	1,600	1,524	2	3,048	904	
10	3,000	1,600	1,524	2	3,048	856	
11	1,800	1,600	1,524	2	3,048	0	
12	1,300	1,600	1,524	2	3,048	0	
13	1,200	1,600	1,524	2	3,048	0	
14	1,000	1,600	1,524	2	3,048	0	
15	1,200	1,600	1,524	2	3,048	0	
16	1,900	1,600	1,524	2	3,048	0	
17	3,400	1,600	1,524	2	3,048	352	
18	3,650	1,600	1,524	2	3,048	954	
19	2,400	1,600	1,524	2	3,048	306	
20	1,000	1,600	1,524	2	3,048	0	
21	800	1,600	1,524	2	3,048	0	
22	760	1,600	1,524	2	3,048	0	
23	300	1,600	1,524	2	3,048	0	
24	300	1,600	1,524	2	3,048	0	
				Max. queued veh.		954	
				Max. queued veh. on 3 lanes		318	
				Average vehicle length		40	ft
				Max. queue length		12,720	ft
						2.41	mi

- As shown in Table 14, the queue starts at 8 AM when the traffic demand (3,400 vph) exceeds the work zone capacity (3,048 vph) and dissipates at 11 AM when the sum of the hourly demand (1,800 vph) and the number (856) of queued vehicles becomes less than the work zone capacity. The queue starts again at 5 PM when the traffic demand (3,400 vph) exceeds the work zone capacity (3,048 vph).
- The maximum number of queued vehicles is 954 at 6 PM when the number of the queued vehicles is the greatest. The maximum number of queued vehicles per lane is

then 318 [954 (vehicles) divided by 3 (lanes)]. Thus, the maximum queue length from the work zone operation is estimated at 2.41 mile [318 (vehicles) multiplied by 40 ft (average vehicle length)].

APPENDIX 4. STATE HIGHWAY TRAFFIC HOURLY DISTRIBUTIONS

Weekday Only:

Hour	AADT Rural (%)	Inbound Rural (%)	Outbound Rural (%)	AADT Urban (%)	Inbound Urban (%)	Outbound Urban (%)
0 - 1	1.62	48.8	51.2	0.9	48.0	52.0
1 - 2	1.30	52.1	47.9	0.6	49.5	50.5
2 - 3	1.30	53.5	46.5	0.6	51.9	48.1
3 - 4	1.52	59.3	40.7	0.8	56.8	43.2
4 - 5	2.14	62.1	37.9	1.6	61.3	38.7
5 - 6	3.43	59.8	40.2	3.1	60.3	39.7
6 - 7	4.79	58.5	41.5	5.0	58.4	41.6
7 - 8	5.30	57.8	42.2	6.0	57.6	42.4
8 - 9	5.12	56.0	44.0	5.8	55.9	44.1
9 - 10	5.10	54.3	45.7	5.5	53.9	46.1
10 - 11	5.24	52.5	47.5	5.4	51.4	48.6
11 - 12	5.43	51.2	48.8	5.8	50.1	49.9
12 - 13	5.63	50.9	49.1	6.0	49.1	50.9
13 - 14	5.74	51.2	48.8	6.1	48.4	51.6
14 - 15	6.11	50.3	49.7	6.5	46.3	53.7
15 - 16	6.57	48.8	51.2	7.0	44.6	55.4
16 - 17	6.73	47.5	52.5	7.0	43.4	56.6
17 - 18	6.40	45.2	54.8	6.5	43.4	56.6
18 - 19	5.32	45.6	54.4	5.4	44.4	55.6
19 - 20	4.31	44.6	55.4	4.2	44.8	55.2
20 - 21	3.57	45.6	54.4	3.5	45.4	54.6
21 - 22	3.03	46.0	54.0	2.9	45.9	54.1
22 - 23	2.40	47.1	52.9	2.2	47.2	52.8
23 - 24	1.88	47.1	52.9	1.4	45.1	54.9
	100.0			100.0		

Weekend Only:

Hour	AADT Rural (%)	Inbound Rural (%)	Outbound Rural (%)	AADT Urban (%)	Inbound Urban (%)	Outbound Urban (%)
0 - 1	1.91	47.6	52.4	1.8	47.7	52.3
1 - 2	1.61	49.5	50.5	1.3	47.8	52.2
2 - 3	1.32	49.0	51.0	0.9	46.5	53.5
3 - 4	1.52	54.9	45.1	0.8	52.2	47.8
4 - 5	1.64	54.9	45.1	0.9	56.3	43.7
5 - 6	2.13	53.0	47.0	1.5	55.5	44.5
6 - 7	2.86	50.8	49.2	2.4	53.2	46.8
7 - 8	3.58	50.4	49.6	3.4	51.6	48.4
8 - 9	4.38	50.0	50.0	4.6	50.9	49.1
9 - 10	5.22	50.7	49.3	5.5	50.2	49.8
10 - 11	5.96	51.3	48.7	6.2	49.8	50.2
11 - 12	6.46	50.6	49.4	6.7	49.1	50.9
12 - 13	6.58	50.9	49.1	7.0	48.7	51.3
13 - 14	6.58	51.3	48.7	7.0	48.5	51.5
14 - 15	6.66	52.4	47.6	7.1	47.9	52.1
15 - 16	6.89	53.1	46.9	7.0	48.1	51.9
16 - 17	6.73	52.9	47.1	6.7	47.9	52.1
17 - 18	6.21	52.6	47.4	6.3	48.4	51.6
18 - 19	5.54	51.5	48.5	5.7	48.4	51.6
19 - 20	4.77	50.7	49.3	5.0	48.9	51.1
20 - 21	4.02	51.4	48.6	4.2	48.8	51.2
21 - 22	3.28	51.4	48.6	3.5	49.5	50.5
22 - 23	2.60	50.7	49.3	2.7	49.6	50.4
23 - 24	1.54	48.6	51.4	1.6	49.8	50.2
	100.0			100.0		